PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

GENERAL LIBRARY
UNIV. OF MICH.

Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CIX.—No. 2831.] *LONDON: FRIDAY, APRIL 2, 1920.* [*Registered at the General Post Office as a Newspaper.*] PRICE... 1s. 2d. BY FOREIGN POST...1s. 5½d.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 8547
Registered Offices: 108A, Cannon St., London, E.C.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches,
BOILER FEED PUMPS.
See Advertisement, pages 33 and 94, last week.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 3179

John H. Wilson & Co., Ltd.
Birkenhead.
See Illustrated Advertisement
Page 124, March 26.

Locomotive Shunting Cranes
Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS,
CONCRETE-MIXERS,
SHIPS WINDLASSES, WINCHES, and
DECK MACHINERY.
6770
LISTS OF STANDARD SIZES ON APPLICATION.
London Office
15, VICTORIA STREET, S.W. 1.

Craig & Donald, Ltd., Machine
TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

CHANTIERS & ATELIERS
Augustin-Normand
67, rue de Perrey—LE HAVRE
(France).
2890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Electric Lifts
(UP TO 25 TONS.)
8143
S. H. HEYWOOD & CO., LTD.,
RHDDISH.

Steam Hammers (with or without guides). Hand-worked or self-acting
TOOLS for SHIPBUILDERS & BOILERMAKERS.
5322
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Brett's Patent Lifter Co.
LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES.
also WINDING, HAULING, AIR COMPRESSING
and PUMPING ENGINES. 1896

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 8207

Telegrams—"Cylinders," Birmingham.
Weldless-Steel Tubes
for Water-tube Boilers, Superheaters,
Shafting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. 3179

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 7766
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3561
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17, March 26. 8206

Electric Cranes.
8143
S. H. HEYWOOD & CO., LTD.,
RHDDISH.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO.,
80, Wellington Street, Glasgow. 7898

Gauges
FROM
Stock.
THE
Newall Engineering Co.
(Proprietors, Peter Hooker, Ltd.),
LONDON, E. 17. 7834

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 8203

Excavators.
FROM 50 TO 600 YARDS PER HOUR.
D. Whitaker,
1, UNION STREET, 7965
LEICESTER.

"Spencer-Hopwood" Patent
Sole Makers:
W. H SPENCER & CO., HITCHIN, HERTS.
See page 15, March 26. 8421

The Cambridge and Paul Instrument
8194
COMPANY, LIMITED.
WORKS: Cambridge and
New Southgate, London, N. 11.

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

FOR
Railway Wagon Couplings
and GENERAL SMITHY WORK,
write
WELDLESS CHAINS, LTD., Coatbridge. 8184

Iron and Steel
Tubes and Fittings.
6920
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 94, Robertson Street, Glasgow.
See Advertisement page 105.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
} Row's PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Tubes and Fittings,
IRON AND STEEL.
Stewarts and Lloyd's, Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM; and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—123, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPCOTE STREET.
See Advertisement page 28. 8187

Die Finished Castings ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to SPARKLETS AND GENERAL MFG. Co., Ltd., Edmonton, London, N. 18.

"Petrolex" Fire Extincteur
puts out flaming motor spirit, burning oil, electric arcs and every kind of fire.—BRITISH FIRE APPLIANCES Co., Ltd., 109, Victoria St., London, S.W. 1.

Locomotive Traversers
(ELECTRIC).
8143
S. H. HEYWOOD & CO., LTD.,
RHDDISH.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also
CAST-STEEL AXLE BOXES. 8337

A Time Recorder, as New, guaranteed, latest model. WHAT OFFERS? —A. G. PELLEY, 149, Farringdon Road, E.C. 1. F 599

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.
Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 15. 7977

Rubber MANUFACTURERS
Packings "Redstone" "Bluestone"
GUTTA PERCHA & RUBBER, LIMITED,
Toronto - - Canada. 8510

Patent
See's Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4836

Diesel Driven Generators,
400-500 Kw., D.C., 500 or 250 Volts, 350 R.P.M., in excellent condition. Low price.
Engines and Dynamos could be sold separately.
Also TWO 500 Kw. Parsons TURBINES, 230-250 Volts, D.C. (in series 460-500 volts), complete with Spare Armature and Condenser.
Exhaust TURBINE SET, Williams-H.C.C., 200 Kw., 440/500 Volts. Complete with Condenser, Pumps, &c.
JENNINGS,
West Walls, Newcastle-on-Tyne. 7969

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 7726

Yarrow Patent
Water-Tube Boilers.
7766
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
MILLWALL, LONDON, E
GENERAL CONSTRUCTIONAL ENGINEERS, 1316
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 2988

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 100, March 26. 3402

George H. Alexander Machinery Ltd.,
83-4, COLESHILL STREET, BIRMINGHAM.
Machine Tools.
SMALL TOOLS. SPECIAL MACHINES.
8488

Steel Castings.
THOMAS SUMMERSON & SONS, LTD.,
DARLINGTON. 7908

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 8143
RHDDISH.

Aluminium Vessels Eliminate Loss Through Rust and Verdigris.
THE BRITISH ALUMINIUM CO., LTD.,
109, Queen Victoria Street, London, E.C. 4.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
7941
See half-page Advertisement page 32, March 19.

See Advt. Page 123, Mar. 26.
Steam Hammers
Power Hammers
Steam and Friction
Drop Stamps.
B. & S. Massey, Ltd., 8393 MANCHESTER.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR. WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901 Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 8443

The Committee of Management

of the Benevolent Fund of the INSTITUTION OF CIVIL ENGINEERS hereby CONVENES an Extraordinary GENERAL MEETING of the Contributors to that Fund, to be held at the Institution, Great George Street, Westminster, S.W. 1, at Four p.m. on MONDAY, the 12th APRIL, for the purpose of appointing a Trustee of the Capital in the place of the late Mr. ANTHONY GEORGE LYSTER. F 658

THE University of Liverpool.

SESSION 1919-20.
LENT TERM BEGINS 8th JANUARY, 1920.
FACULTY OF ENGINEERING.
DEAN—Associate Professor J. WEMYSS ANDERSON, M.Eng., M.Inst.C.E., M.I.Mech.E.
PROFESSORS AND LECTURERS.
ENGINEERING,
Harrison Professor—W. H. WATKINSON, M.Eng., M.Inst.C.E., M.I.Mech.E., M.I.E.E.
Assistant Professor—W. MASON, D.Sc., A.M.Inst.C.E.
Lecturer—G. H. SCHOLES, M.B.E., M.Sc., A.M.I.E.
ELECTRICAL ENGINEERING.
David Jardine Professor—E. W. MARCHANT, D.Sc., M.I.E.E.
Lecturer—F. J. TEAGO, B.Sc., A.M.I.E.
Lecturer in Municipal Electrical Engineering—Associate Professor A. BROMLEY HOLMES, M.Eng., M.Inst.C.E., M.I.E.E.
CIVIL ENGINEERING.
Professor S. W. PERROTT, M.A.I., M.Inst.C.E.
Lecturer in Railway Engineering—Associate Professor Sir J. A. F. ASPINALL, M.Eng., F.Inst.C.E., M.I.Mech.E.
Lecturer in Municipal Engineering—Associate Professor J. A. BRODIE, M.Eng., F.Inst.C.E., M.I.Mech.E.
Lecturer in Dock and Harbour Engineering—Vacant.
Lecturer in Dock and Harbour Construction—T. R. WILTON, M.A., Assoc.M.Inst.C.E.
NAVAL ARCHITECTURE.
Alexander Elder Professor—T. B. ABELL, M.Eng., R.C.N.C., Ret., M.Inst.N.A.
MARINE ENGINEERING.
Professor and Lecturers in Naval Architecture and Engineering.
DESIGN AND DRAWING, REFRIGERATION.
Associate Professor J. WEMYSS ANDERSON, M.Eng., M.Inst.C.E., M.I.Mech.E.
MATHEMATICS.
Professor—F. S. CAREY, M.A.
PHYSICS.
Lyon Jones Professor—L. R. WILBERFORCE, M.A.
Lecturer—J. RICE, M.A.
CHEMISTRY.
Grant Professor—H. C. C. BALY, C.B.E., M.Sc., F.R.S., F.I.C.
GEOLOGY.
George Herdman Professor—P. H. G. BOSWELL, O.B.E., D.Sc.
The Prospectus of the Faculty may be obtained on application to the undersigned.
EDWARD CARRY, Registrar.
C 972

Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "D" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434, Offices of ENGINEERING.

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 9-10, Trafford Chambers, 56, South John Street, Liverpool. 8421

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 8394

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 384, Oxford Road, Manchester.

TENDERS.

RHONDDA URBAN DISTRICT COUNCIL.

The above-named Council

Require 1800 Yards of Good

SECOND-HAND STEEL 14-16 lbs. JUBILEE RAILWAY attached to Steel Sleepers for 24 in. gauge.
20 Sets of new or good SECOND-HAND JUBILEE POINTS and CROSSINGS 16 ft. 6 in. long, attached to Steel Sleepers for 24 in. gauge.
20 new or good SECOND-HAND TURN TABLES for 24 in. gauge.

One Electric 5-10 HP. Single Pulley Endless Rope HAULAGE ENGINE. Complete.
2000 yards ¾in. STEEL WIRE ROPE and ROLLERS

The lowest or any Tender will not necessarily be accepted.
Tenders enclosed in a sealed envelope (endorsed on the outside "Light Railway" or "Electric Haulage," as the case may be) should be delivered at my Office not later than Monday, the 19th day of April, 1920.
Dated this 26th day of March, 1920.
THO. HUGHES,
Clerk.
District Council Offices,
Ebbw Vale. F 621

For Sale by Tender.

One 50 Kw. Bellise & Morcom D.C. GENERATING SET, 440 volts; also Spare Armature for same.
LANCASHIRE BOILER, 24 ft. by 7 ft. by 160 lbs. With Hopkinson Valves, Meldrum Sprinkler on 4 HP Motor.
WEIR PUMP, Separator and all accessories, complete, and nearly new. Apply to
THE HAFOD MANFG. CO., LTD.,
Pipe House Wharf,
Hafod, Swansea. F 665

COUNTY BOROUGH OF SALFORD.

ELECTRICITY DEPARTMENT.

The Electricity Committee have

For Sale, Two Lancashire

BOILERS, 9 ft. diameter by 30 ft. long.
Full particulars may be obtained from the Borough Electrical Engineer, Electricity Works, Frederick Road, Salford.
Tenders are invited not later than Twelve noon, on Monday, 12th April, 1920.
L. C. EVANS, Town Clerk. F 554

CLYDE LIGHTHOUSES TRUST.

The Trustees invite

Enquiries for the Sale or Hire

of their DREDGER "WILLIAM H. RAEBURN" which is in excellent order. The Dredger is at present in the West Harbour, Port Glasgow. It is capable of dredging 500 tons per hour at 42 feet depth, self-propelling, speed 5 knots; two sets of buckets large and small.
Further particulars of the vessel from Messrs. D. & C. STEVENSON, Civil Engineers, 84, George Street, Edinburgh.
Enquiries for sale or hire to be made to the undersigned.
J. F. ANDERSON,
Clerk to the Trustees.
137, St. Vincent Street,
Glasgow.
11th March, 1920. F 317

GOVERNMENT OF WESTERN AUSTRALIA.

The AGENT-GENERAL for WESTERN AUSTRALIA is prepared to receive

Tenders for—

A. ONE 7500 KW. TURBO-ALTERNATOR,
B. CONDENSING PLANT FOR THE ABOVE,
which are required for an extension to the existing Government Power Station at Perth.
Specifications and Forms of Tender are issued separately for the Turbo-Alternator and for the Condensing Plant. They may be obtained from the AGENT-GENERAL FOR WESTERN AUSTRALIA on or after Wednesday, 7th April, 1920. Any bona fide Tenderer requiring information in addition to that contained in the specification may apply to the Consulting Engineers, Messrs. MERZ & MCLELLAN, 32, Victoria Street, Westminster, London, S.W. 1.
The charge for either of the specifications in duplicate is £5 5s., and £2 2s. each for any further copies. Sums paid for the original specifications (in duplicate), but not for further copies, will be refunded on receipt of a bona fide Tender for the whole of the work included in the specification or specifications as the case may be. Cheques (crossed) in payment for these specifications must be made payable to the Agent-General for Western Australia.
Sealed Tenders in duplicate, marked "Government of Western Australia—Tender for Turbo-Alternator," and/or "Government of Western Australia—Tender for Condensing Plant," are to be addressed to the AGENT-GENERAL FOR WESTERN AUSTRALIA, at his Office, Savoy House, Strand, London, W.C. 2, not later than Twelve noon, on 14th May, 1920.
The Government do not bind themselves to accept the lowest or any Tender, and ample security will be required from the Contractor whose Tender is accepted. F 646

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.
(PLANT AND MACHINERY SECTION.)

For Sale by Public Tender.

MISCELLANEOUS PLANT
Located at LOCKBURN WORKS, MARYHILL; SHANNON STREET; and CASSEL CYANIDE CO.'s WORKS, GLASGOW.
Comprising:—
Rotary SWAGING MACHINES.
30 and 40 Ton Single Speed DRAW BENCH (Motor Driven) and Starters. Twin Chamber Muffle.
12 Morgan's Patent TURNING FURNACES (Type S.A.).
TURNTABLES for Billet Mould.
"Sentinel" Belt-driven AIR COMPRESSORS.
8 0 HP. Open Type Induction MOTOR, by Crompton.
Westinghouse (Morse) Rocker Joint CHAIN DRIVES.
TANKS (Various).
Cylindrical MIXING DRUMS. Drives (various).
SPECIAL FURNACE, for Heating Drums and Storing Liquid under Heat.
Oak Vat. Shafting. C.I. Mitre Wheels. C.I. and W.I. Piping, etc.
Offers for individual lots considered.
For particulars, permit to view, and Tender Form can be obtained on application to the CONTROLLER, Plant and Machinery (D.B.I.e.), Charing Cross Huts, Embankment, London, W.C. 2.
Tenders to be returned on or before 10 a.m., 26th April, 1920.
NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. F 624

OLDHAM CORPORATION WATER WORKS.

Tenders are Invited for the

following:—
One HORIZONTAL ENGINE, with 2 in. starting valve, 9½ in. cylinders by 16 in. stroke, with 5 ft. dia. C.I. Fly Wheel with Governors, etc., and cast iron bed plate, 8 ft. 8 in. long, together with feed pump with 1 in. ram, with necessary syphon and exhaust taps, on stone foundation 10 ft. by 2 ft. 8in., with iron fencing.
One VERTICAL BOILER, 8 ft. by 2 ft. 9 in. dia., with Injector, Safety Valves, Gauge Taps, etc.
One STONE CRUSHER, by Robert Broadbent, Stalybridge, with two 5 ft. fly wheels, driving pulley, 36 in. by 7 in., with 21 in. jaws.
The Machinery and Crusher to be removed by and at the expense of the person tendering.
For permission to inspect the Machinery and Crusher, applicants should apply to Mr. C. J. BATLEY, Engineer, Piethorne, Near Rochdale.
Offers for the material should be addressed to Mr. ERNEST PARRY, Commercial Superintendent, Water Office, Oldham, and sent not later than the morning of Tuesday, the 6th of April. F 543

APPOINTMENTS OPEN.

UNIVERSITY COLLEGE, NOTTINGHAM.

DEPARTMENT OF ENGINEERING.

Junior Lecturer in Mechanical

Engineering WANTED to commence duties as early as possible in the Summer Term, 1920. Commencing Salary £250 per annum.
Further particulars and application forms may be obtained from the REGISTRAR, to whom they should be returned not later than April 12th. F 583

UNIVERSITY OF LIVERPOOL.

FACULTY OF ENGINEERING.

Assistant Lecturer and

DEMONSTRATOR in Mechanical Engineering. The Council INVITE APPLICATIONS for this POST. Commencing salary £300 per annum, plus war bonus. Full particulars from the REGISTRAR. F 545

Demonstrator for Drilling

(One). DEMONSTRATOR for TURNING and BORING (One). DEMONSTRATOR for FITTING (One).—A large Firm of Motor Engineers in South of England invite applications for the above positions. Applicants must be reliable, tactful and thoroughly experienced. Only real, live men who have held responsible positions need apply. These are Staff Appointments and permanent jobs to the right sort of men. Past experience and age must be stated.—Address, F 623, Offices of ENGINEERING.

LONDON COUNTY COUNCIL.

Applications are Invited from

persons desirous of having their names placed on the panel of Instructors in (a) ENGINEERING, (b) PATTERN-MAKING, (c) METAL-PLATE WORK, (d) INSTRUMENT-MAKING for employment, as required, in the trade courses conducted at the junior technical evening institutes. Salary 15s. an evening of two hours' duration.
Apply to the EDUCATION OFFICER (T. 6), Education Offices, Victoria Embankment, W.C. 2 (stamped addressed foolscap envelope necessary). Form T 17 (p) will then be sent, and must be returned by 11 a.m. on 8th April, 1920. Canvassing disqualifies. Preference will be given to persons who have served or attempted to serve with the Forces of the Crown.
JAMES BIRD,
Clerk of the London County Council.
F 635

RANGOON PORT COMMISSIONERS.

Wanted, as Chairman of the

COMMISSIONERS FOR THE PORT OF RANGOON, a gentleman of proved organising ability, with practical experience in business, railway or port administration, not over 45 years of age. Salary to be fixed according to qualifications, but to be not less than Rs. 3000 a month with a free house.
The appointment will be on an agreement for five years with power to extend the period for further period of five or 10 years by mutual consent.
Applications should be addressed not later than the 20th April, to Messrs. OGILVY, GILLANDERS AND CO., Sun Court, 67, Cornhill, London, from whom further particulars regarding the appointment may be obtained. F 643

ROYAL AIR FORCE. BOYS' TRAINING CENTRES.

TEMPORARY APPOINTMENTS ON EDUCATIONAL STAFF.

The Services of a

limited NUMBER of TEACHERS are REQUIRED for duty in the Boys' Training Centres at Halton, near Wendover, Bucks, and at Flowerdown, near Winchester, to give instruction in some or all of the following subjects:—English, Practical Mathematics, Mechanics, Heat and Electricity.
Rate of Salary, £250 to £300, according to qualifications and experience.
Teachers appointed to these temporary posts, whose work is well reported upon, and who have the requisite academic qualifications, will be considered for transfer to the permanent staff as vacancies occur.
Applications giving full particulars in regard to age, education, training and experience, together with copies of recent testimonials, should be forwarded immediately to the SECRETARY (T.2 B), Air Ministry, Kingsway, W.C. 2. F 384

Wanted for Canadian Works,

ESTIMATOR on Plate Work. Thoroughly familiar with shop methods and up-to-date practice.—Apply, stating age, experience, salary required, and when available.—INGERSOLL-RAND CO., 165, Queen Victoria Street, London. F 647

Assistant Chemist Wanted for

Steel Works laboratory. Experience in rapid analysis of alloy steels essential.—Address, stating age, qualifications and salary required, F 606, Offices of ENGINEERING.

Wanted, Capstan Setter-Up

used to Herbert Machines, for Commercial Vehicle Manufacturers in the North.—Address, stating previous experience, age and salary required, F 513, Offices of ENGINEERING.

Wanted, Cost Clerk, Young

Man, 25-30, preferably trained in Engineering Works Office. Must be experienced in modern methods of keeping cost records, wages and material. Cardiff District.—Address, stating age, experience in detail, salary required, F 236, Offices of ENGINEERING.

Clerical Assistant Wanted for

Civil Engineer's Office. Thorough knowledge of costing, estimating, quantities, capable of conducting correspondence and general office routine.—Write, stating age, experience and salary required, to BOX S776, LEE & NIGHTINGALE, Advert. Offices, Liverpool. F 634

Gentleman Required (not over

25), preferably with past practical experience in the Machine Tool Trades, to take charge of department for Estimating, Sales and Publicity. A unique chance for the right man to make a position for himself in a progressive and established concern in London. Offers will be treated in confidence.—State salary expected, age, and whether married, and give details of past career, to BOX 330, c/o JUDDS, 97, Gresham Street, E.C. 2. F 640

Rate Fixer.—A Large Engi-

neering concern in the Manchester district, REQUIRE an experienced manufacturing ENGINEER to organise and control rate fixing department. Applications only invited from those who are conversant with latest manufacturing methods of electrical and mechanical details in machining and assembling operations. Good education and tactful disposition indispensable. State age, experience and salary required.—Address, F 350, Offices of ENGINEERING.

Drawing Office Quantities

CLERK REQUIRED by London Constructional Engineers for scheduling quantities from working drawings.—Address in strict confidence, stating previous experience, age, and salary required to F 671, Offices of ENGINEERING.

Junior Clerks (Male), Wanted

for City Office of large Petrol and Petroleum Distributing Concern; age 20-22, good writing, quick at figures, good education essential, and knowledge of purchasing of Engineering Supplies, Piping, Valves, etc., an advantage.—Reply, stating age, experience, salary required, also send copies of any testimonials and school character, to Z. S. 434, care of Messrs. DEACON'S, Leadenhall Street, E.C. F 662

Wanted for Export Merchants

office, EXPERT in the manufacture and purchase of light railway materials.—Write, stating age, experience and salary required, to Z.T. 436, care of Messrs. DEACON'S, Leadenhall Street, London, E.C. F 661

Wanted, Night Shift Machine

SHOP SUPERINTENDENT for large Commercial Vehicle Manufacturers in the North. Must be first-class man used to up-to-date methods and a knowledge of all classes of machines.—Address, stating previous experience, age and salary required, F 514, Offices of ENGINEERING.

Foundry Manager.—Wanted

a practical and energetic man to TAKE CONTROL of a large Iron and Brass Foundry; preference given to one having experience in economical production of large and small castings. Applicants should give particulars of their experience, and also state age, and salary desired. Applications will be treated as strictly confidential.—Address, F 620, Offices of ENGINEERING.

Electrical Engineer Wanted

by old-established firm of Engineers in the North, to take charge of electrical branch just opened. Estimating, quoting and supervision of lighting and power plants for factories and private houses. Armature repairs, etc., mechanical experience an advantage. State experience supported by testimonials. Good prospects for suitable man.—Address, F 633, Offices of ENGINEERING.

Wanted, a Young, Energetic,

Qualified CIVIL ENGINEER, with experience on Harbours and Railways. Must be good Draughtsman, Estimator and Field Surveyor.—Write, stating age, salary expected, and when available, also enclosing references, BOX E 764, LEE & NIGHTINGALE, Advert. Offices, Liverpool. F 567

Wanted in a Marine Engine

Works, an ENGINEER experienced in modern methods of production.—Address, F 526, Offices of ENGINEERING.

Electrical Engineering Assis-

TANT WANTED for office of large manufacturing firm in S.W. London; sound theoretical training and experience (preferably on test bed) in running D.C. plant essential; age 25-28. State age, training, experience, and salary required.—Address, F 670, Offices of ENGINEERING.

Chief Engineer Wanted for

Large Steel Works to take full responsibility for maintenance of Steam, Electrical, Hydraulic and other plant. Must be good organiser, capable administrator and able to control men. Apply in confidence, stating age, previous experience, references and salary required, to F 666 Offices of ENGINEERING.

Engineer Wanted at Chase

Farm Schools, Enfield, competent to take charge of and execute running repairs to Galloway and Cornish Boilers. Steam Laundry Plant, Hot Water Heating and Steam Fittings, Calorifiers and Electric Lighting.—Application, stating age, experience and salary required, with copies of not more than three recent testimonials, to be made to SUPERINTENDENT. F 672

Wanted, Draughtsman, with

first-class knowledge of Modern Motor Car design.—Address, stating experience and salary required, F 616, Offices of ENGINEERING.

THE MACHINERY OF H.M. AIRSHIPS R. 33 AND R. 34.

HAVING recently illustrated and described* the general construction of H.M. Rigid Airship R. 34, and given an account of the notable transatlantic voyages accomplished by this airship, it may be of interest to illustrate and describe the machinery installation with which the vessel is fitted. The R. 34, it will be remembered, was built by Messrs. William Beardmore and Co., Limited, and the propelling machinery for this airship, and also for its sister ship, the R. 33, was constructed by the Sunbeam Motor Car Company, Limited, of Moorfield Works, Wolverhampton, to whom we are indebted for the drawings and photographs of the machinery reproduced on Plate XXV and the present page. The general dimensions and some other data relating to the airships are given in tabular form on Plate XXV.

Before describing the machinery in detail it will, perhaps, be advisable to repeat what has already been published in the article above referred to with regard to the general arrangement of the propelling machinery. There are in all, five cars or gondolas, supported from the main structure of the ship. Of these the two foremost are situated on the centre line of the ship, one immediately behind the other, so as virtually to form a single car. Of these two cars the forward one is used exclusively for navigation purposes, while the after one contains a single Sunbeam-Coatalen "Maori" type engine, of 270 h.p., driving a "pusher" air screw through a permanent reduction gear. In a position rather forward of amidships two wing cars are suspended, one on each side of the centre line, at a slightly higher level than the forward car. These cars also contain engines of the Maori type, driving pusher screws, through a reduction gear, but a reversing gear is incorporated with the reduction gear in these cars, so that the air screws can be reversed for manœuvring purposes. The remaining car is situated on the centre line of the ship towards the after car, and contains two Maori engines, both driving a single air screw.

A plan of the after car is reproduced in Fig. 1 on Plate XXV, while Fig. 2 is a cross-section taken through the fifth frame from the forward end. Fig. 5 is an interior view of the car looking towards the propeller and showing the forward engine in the foreground; while Fig. 7, above, is a view showing the after portion of the car only. The flexible pipes conspicuous in this illustration are the water connections to the radiator, and they are designed to allow the latter to be moved vertically so as to enable the temperature of the cooling water to be regulated by exposing more or less of the radiator to the air. The large pipe shown in Fig. 5 is an air inlet trunk for ventilation purposes. From the plan, Fig. 1, it will be seen that the two engines are placed with the centre lines of their crankshafts 150 mm. on either side of the centre line of the car, each engine driving a separate pinion of the reduction gear. Generally speaking, the lay-out of the machinery in each car is similar; but for the purpose of description we shall refer particularly to the arrangement of the wing car, calling attention to any variations in detail where necessary.

A longitudinal section and plan of the port wing car are given in Figs. 3 and 4, while Fig. 6 is a reproduction of a photograph of the interior of the starboard wing car. In all cases the engine is coupled to the reduction gear through a flywheel, multiple disc clutch, and an intermediate shaft with a universal coupling of the tooth type, which is fitted to allow for any distortion which may take place in the car framework. The flexibility of the support for the transmission units was one of the chief problems to be overcome in designing the installation, but the tooth-type couplings and the girder supports for the intermediate shaft, best shown in Fig. 4 have obviated any trouble from this cause.

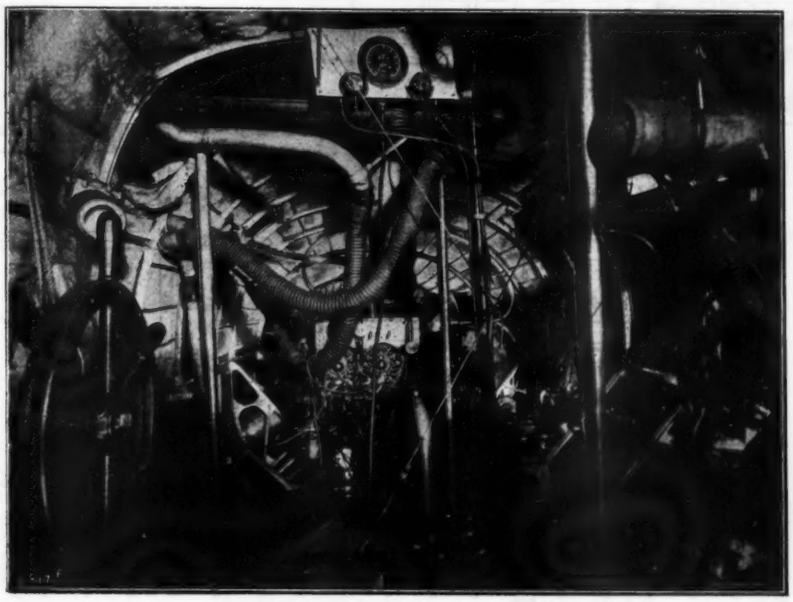


FIG. 7. AFT ENGINE IN AFT CAR. R 33.

In a subsequent article we propose to deal fully with the design and construction of these engines, confining out attention, for the time being, to the transmission gear. We may here mention, however, that each engine is fitted with a flywheel sufficiently heavy to enable it to run when disconnected from the air screw. This flywheel drives the transmission by means of blocks of resilient material fitted into recesses machined in the inner surface of a driving ring formed on the face of the flywheel, the blocks being faced with hard brass held in position by small wire clips. Close to the flywheel and distinguishable in Figs. 1, 3 and 4, is a clutch of the corrugated multiple disc type, composed of an equal number of bronze and steel plates arranged alternately. Figs. 3 and 4 also show the method of operating the clutch from a vertical lever placed forward of the engine and connected to a horizontal lever on the clutch by means of a wire cable taken round two pulleys. A central spring is fitted, and is operated by eccentric links and pins through two ball thrusts, this arrangement serving to balance the spring thrust when running, and also largely to diminish the end thrust on the whole gear when declutching. The clutch shaft is separately supported on double rows of ball bearings with spherical races, so as to give flexibility. The clutch is connected to the gear box by means of a short intermediate shaft with tooth-type couplings, already referred to, at each end. The teeth, it may be mentioned, are lozenge-shaped so as to give greater flexibility. The gear case is constructed of well-webbed aluminium castings, and the method of fitting it in the wing cars is shown in Figs. 3 and 4. The propeller-shaft, it will be noticed, is vertically under the pinion-shaft and the gears give a speed reduction ratio of 1 : 3·86. The flange to which the propeller is bolted is forged solid with the shaft, and the loose outer flange is keyed on to the end of the shaft in the usual manner. The shaft is supported on two roller bearings, one on each side of the gear-wheel, which is fitted immediately behind the propeller, and the inner bearings are also of the roller type. The thrust of the propeller is taken by a thrust race formed by two spherical-shaped washers and one row of balls, the clearance being arranged so that this single row takes the thrust in either direction.

The reverse mechanism is of the usual sliding sleeve pattern, the countershaft, which is arranged on the port side of the gear-box, as indicated by the chain-dotted line in Fig. 4, carrying the main sliding sleeve, which is formed of two wheels. Only the two main reduction wheels are in engagement in forward driving, the sleeve on the driving shaft then having its clutch engaged with the pinion shaft. A brake is mounted on the driving shaft, and by this means the rotation of the propeller may be stopped when declutching. Reversing is effected by the manipulation of two levers, one connected to each of the two sleeves. The arrangement is perhaps rather more liable to misuse than the more common form of gate change used in motor car practice, but among other points in its favour, is the decided advantage, above mentioned, that only two gear wheels are in mesh when running in the normal direction. Reversing is, of course, only necessary when landing or manœuvring for a landing, so that the gear is only in use for a very small percentage of the total time of running the engine.

The construction of the reduction gear for the forward car is very similar to that above described, except that, in this case, no reversing gear is fitted. Lubrication, in both cases, is effected by means of an oil pump which directs a stream of oil between the teeth at the point of contact. An auxiliary tank is provided so that a large quantity of oil is circulated, and any heat generated is readily dissipated. Large vent pipes are also fitted to the gear boxes as shown in Fig. 4, and these induce a flow of air through the boxes when the airship is under way, thus cooling them very effectively.

In the case of the after car, which contains two engines, both engines are fitted with clutches similar to those previously described. The power from the forward engine is transmitted through a long intermediate shaft, shown in Fig. 1, passing just clear of the bearers of the after engine. This shaft, and the short shaft from the after engine, are both fitted with tooth couplings as mentioned in connection with the wing cars. The shafts run in double ball bearings mounted on transverse bearers, and similar bearings are also housed inside the end of the pinion shaft of the gear-box. Close to the gear-box, and shown on the left in Fig. 1, sliding dog clutches are fitted so that either, or both, of the engines can be completely disconnected from the propeller at will. In the gear-box, which has the same speed reduction ratio as those already mentioned, viz., 1 : 3·86, both of the pinion shafts are situated above the propeller shaft. They are very short and of large diameter, and are mounted in roller bearings and fitted with brake drums. The propeller shaft in this car differs somewhat in design from those in the other cars. Reference to Fig. 1 will show that it is mounted on two cross-members and not enclosed in the gear-box. The drive from the main gear wheel shaft to the propeller shaft is by means of a dog clutch. The aft

* See vol. cviii, page 87.

end of the shaft is supported by a roller-bearing, and also carries a single row thrust bearing. As will be seen from the illustration, the cross-member carrying the bearing is very short and is of box construction of sufficient strength to transmit to the car the thrust from the large propeller which is 19 ft. 6 in. in diameter and absorbs 540 h.p. The other three propellers are 17 ft. 6 in. in diameter, and each absorbs 270 h.p. The double gear of the after car is lubricated, as previously described, by means of a pump and auxiliary tank, and a special connection from the system is taken to the aft end of the car to lubricate the thrust and roller bearings. The oil cooling tanks are clearly shown in Figs. 1 and 2

(To be continued.)

THE ARMSTRONG SHIPYARD.

(Continued from page 370.)

As mentioned in our previous article the reinforced-concrete portion of the jetty between the two largest building berths has a length of 350 ft., and is 30 ft. wide at the deck level. There are two other jetties 300 ft. and 200 ft. in length, respectively, between the second and third and third and fourth berths, and except in the matter of length, all three jetties are of practically identical construction.

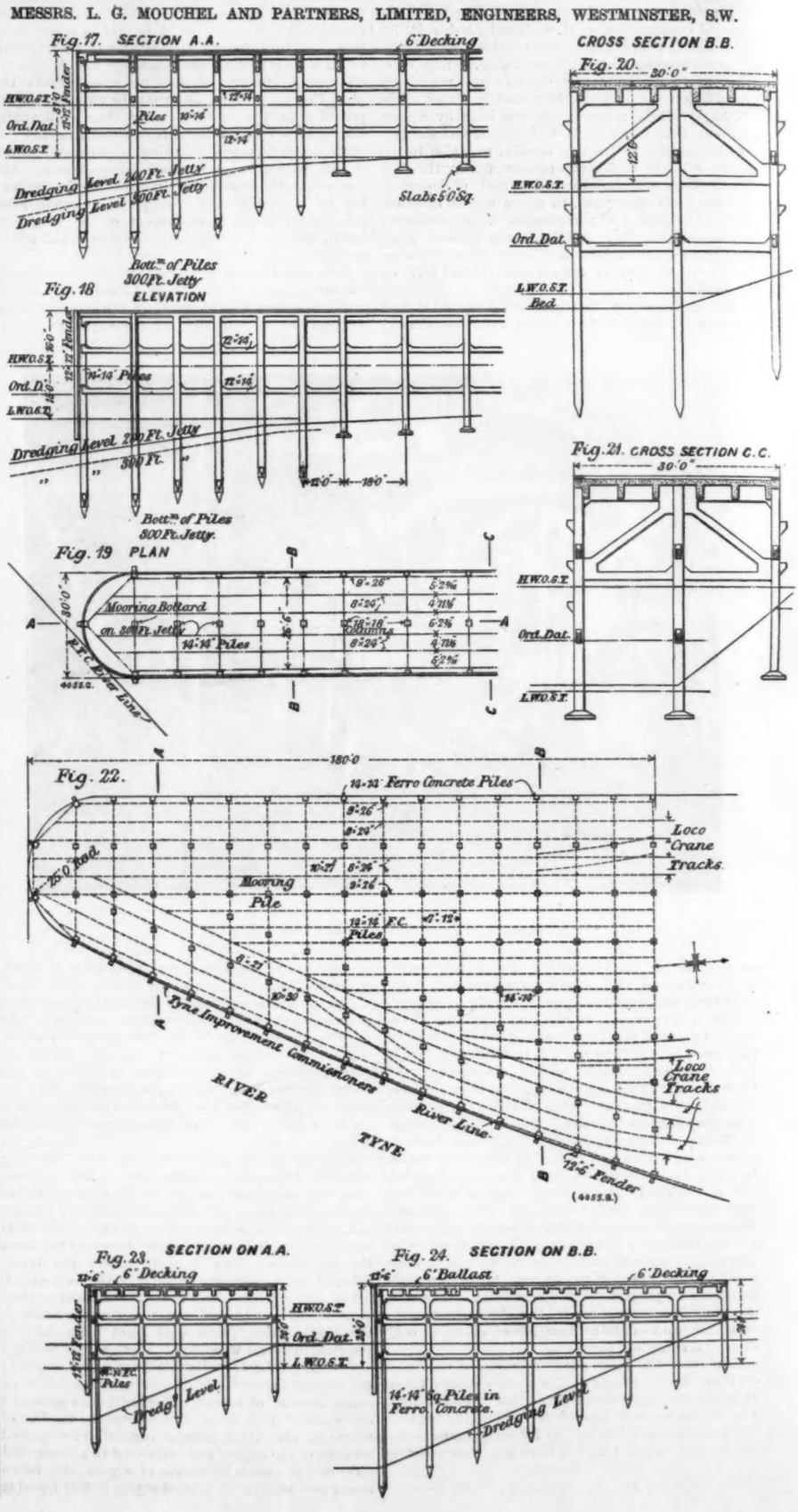
The drawings reproduced in Figs. 17 to 21 annexed show the construction of the river-end portion of one of these jetties, Fig. 17 being a longitudinal section, Fig. 18 a side elevation, and Fig. 19 a plan; Figs. 20 and 21 are cross sections. The jetties, like all the other reinforced concrete work in the yard, were designed on the Hennebique system by Messrs. L. G. Mouchel and Partners, of 36 to 38, Victoria-street, Westminster, London, S.W.1. Above low-water level, where good foundations were obtainable, the jetties were built on 18 in. by 18 in. columns with extended footings arranged in three rows spaced on 18-ft. centres in a longitudinal direction; but below low water level the jetties were constructed of 14 in. by 14 in. piles at intervals of 12 ft. These piles were driven to a depth of about 60 ft. below deck level. The horizontal bracings used were of 12 in. by 14 in. section in all cases, and they were placed 12 ft. 6 in. and 24 ft. 6 in. below the deck level; inclined lateral bracings were also employed as shown in the cross-sections Figs. 20 and 21. The spacings and sections of the deck beams are given in the plan Fig. 19, and this figure also shows the semi-circular end formed on each of the jetties. The outer piles at the end of the jetties, it will be noticed, are protected by 12 in. by 12 in. fenders, and the river bed was dredged to give a depth of 15 ft. at low water. All the jetties were designed to carry a load of 6 cwt. per square foot in addition to the travelling electric tower crane and two 10 ton locomotive steam cranes. The maximum load due to the tower crane would be 50 tons on two wheels three feet apart, and the corresponding figure for the steam cranes would be 35 tons on one wheel.

Before dealing with the fitting-out quay in detail it will be convenient to describe the piled roundhead with which the quay terminates at its southern end. A plan of the roundhead is reproduced in Fig. 22 annexed, and it should be noted that the straight upper edge in this illustration forms the boundary of the 1,000 ft. building berth, while the curved lower edge is a continuation of the fitting-out quay. In general, the construction of the roundhead is similar to that of the jetties above described, and it is designed for the same loading. The roundhead is built on 14 in. by 14 in. reinforced concrete piles, spaced about 11 ft. apart in a longitudinal direction, and about 14 ft. apart laterally. The horizontal bracing members, which are of 12 in. by 14 in. section, are arranged as shown in the cross-sections, Figs. 23 and 24, which also show how the lengths of the piles vary from about 60 ft. on the river side to about 25 ft. on the berth side. The deck is formed of reinforced concrete 6 in. in thickness, covered with 6 in. of ballast, and the plan Fig. 22, shows the positions and dimensions of the floor beams and the crane tracks. The total length of the roundhead measured parallel with the 1,000-ft. berth, is 180 ft., and the width varies from 50 ft. to 111 ft. 6 in.

The extensive fitting out quay, which forms one

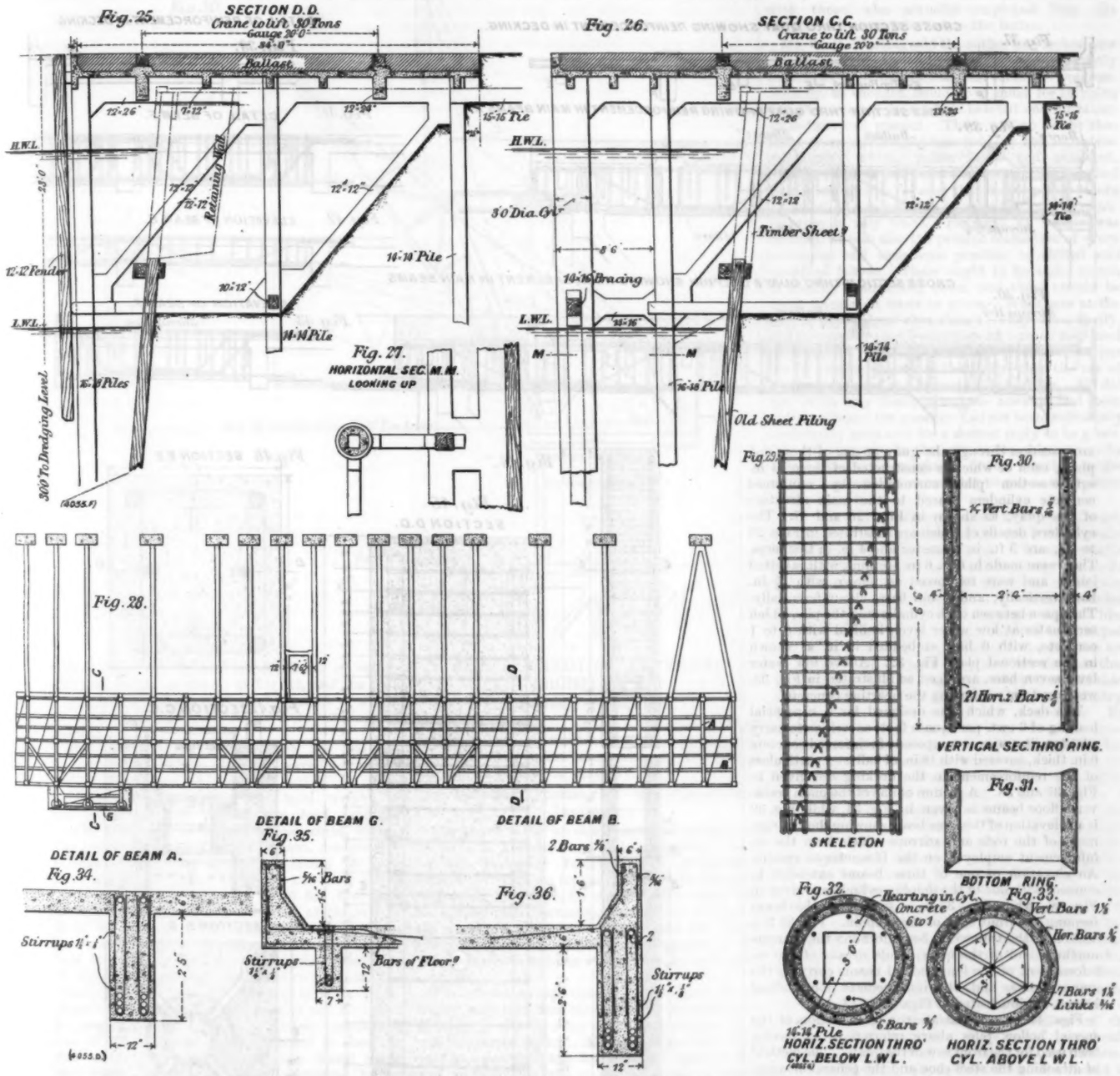
ARMSTRONG YARD; REINFORCED CONCRETE WORK.

MESSRS. L. G. MOUCHEL AND PARTNERS, LIMITED, ENGINEERS, WESTMINSTER, S.W.



ARMSTRONG SHIPYARD; REINFORCED CONCRETE FITTING-OUT QUAY.

MESSRS. L. G. MOUCHEL AND PARTNERS, LIMITED, ENGINEERS, WESTMINSTER.



of the most striking features of the yard, has a length of 2,133 ft., without including the piled roundhead, and it can thus accommodate three large vessels without overlapping. As mentioned in our previous article the river bed was dredged to give a depth of from 30 ft. to 32 ft. at low water of ordinary spring tides, which is sufficient to take the largest mercantile vessels unless they are fully loaded; but it may here be mentioned that deep water moorings suitable for vessels up to 800 ft. in length, and drawing up to 34 ft. of water, are provided on the farther side of the river opposite the ends of the largest building berths; these moorings are shown on the key plan, Fig. 1, page 367 *ante*. A cross-section of the quay is given in Fig. 25 above, and from this it will be seen that the quay is formed by reinforced concrete decking carried on three rows of piles which are also of reinforced concrete. The piles in the front row, which are of special hollow construction, measure 16 in. by 18 in. in section, and have an average length of 63 ft. from toe to deck level. We shall illustrate and describe the construction of these special piles a little later on. The piles in the middle row and back row average 55 ft. and 50 ft. in length, respectively, and both are 14 in. square in section. The piles are spaced 12 ft. apart along the quay and about 16 ft. apart laterally, the total width of the decking being 34 ft. 6 in.; the height of the decking above low water level is 23 ft. Horizontal bracing of 10 in. by 12 in. section is placed at about 2 ft. 6 in. above low water level. It will have been noticed from the cross-section, Fig. 25, that the ground slopes downwards from the back of the quay to the middle row of piles, from which line it runs horizontally towards the front row of piles. It is retained by sheet piling, which is of timber in some places and of reinforced concrete in others. The sheet piles are about 40 ft. long, and the toes are driven to about 10 ft. below the bed of the river. The position of the old retaining wall, which was removed for the construction of the present quay, is indicated in Fig. 25. Diagonal bracing, shown in the plan, Fig. 28, is provided to transmit the earth pressure from the sheet piling through horizontal reinforced concrete ties to concrete anchor blocks buried in the ground at deck level. The ties are 15 in. square and 60 ft. in length, and the concrete blocks measure 4 ft. by 6 ft. by 8 ft. Similar ties and anchor blocks are provided to take the pull on the bollards, which are designed for a load of 60 tons.

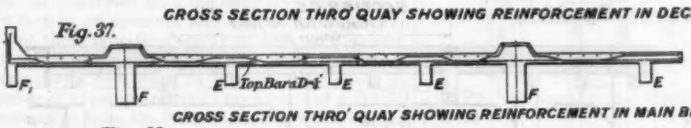
Equally spaced along the front of the quay are nine dolphins, each of which has a length of 30 ft., and projects a distance of 8 ft. 6 in. Fig. 26 is a

ARMSTRONG SHIPYARD; REINFORCED CONCRETE FITTING-OUT QUAY.

MESSRS. L. G. MOUCHEL AND PARTNERS, LIMITED, ENGINEERS, WESTMINSTER.

CROSS SECTION THRO' QUAY SHOWING REINFORCEMENT IN DECKING.

Fig. 37.



DETAIL OF REINFORCEMENT IN DECKING.

Fig. 38.

CROSS SECTION THRO' QUAY SHOWING REINFORCEMENT IN MAIN BEAMS 'A'

Fig. 39.

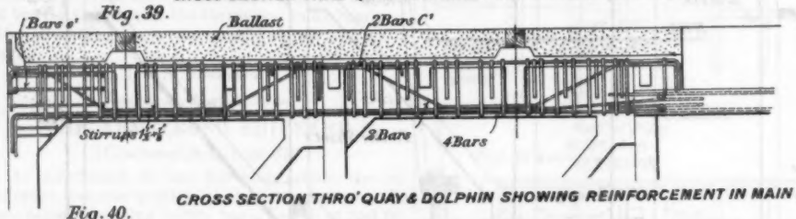
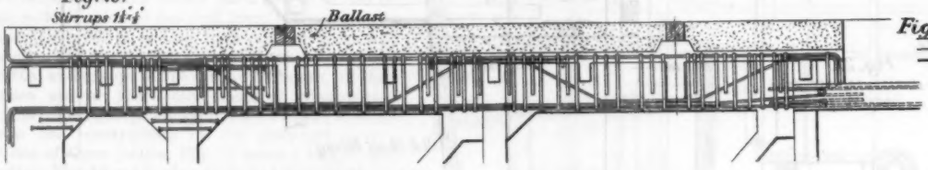


Fig. 41. DETAIL OF BEAM F.

Fig. 42. ELEVATION OF BEAM E.

CROSS SECTION THRO' QUAY & DOLPHIN SHOWING REINFORCEMENT IN MAIN BEAMS.

Fig. 40.



ELEVATION OF BEAM F,

Fig. 43.

cross-section through the quay at one of these dolphins, each of which is constructed of three 14 in. square-section piles surrounded by reinforced concrete cylinders braced to the main structure of the quay, as shown in Figs. 26 and 27. The cylinders, details of which are illustrated in Figs. 29 to 33, are 3 ft. in diameter and 4 in. in thickness. They were made in 6 ft. 6 in. sections, with rabetted joints, and were reinforced as shown with $\frac{7}{16}$ in. bars vertically, and $\frac{3}{8}$ in. bars circumferentially. The space between each cylinder and the pile, which terminates at low water level, is filled with 6 to 1 concrete, with 6 bars embedded in it, as shown in the sectional plan, Fig. 32. Above low water level seven bars, arranged as illustrated in Fig. 33, were used for reinforcing the hearting concrete.

The deck, which was designed for a superficial loading of 6 cwt. per square foot, as well as to carry a 30-ton jib crane, is composed of reinforced concrete 6 in. thick, covered with 18 in. of ballast; particulars of the reinforcement in the decking are given in Figs. 37 and 38. A section of one of the main transverse floor beams is given in Fig. 34, while Fig. 39 is an elevation of the same beam showing the arrangement of the rods and stirrups which form the reinforcement employed on the Hennebique system. An elevation of one of these beams extended to connect with one of the dolphin cylinders is given in Fig. 40, while Fig. 35 is a section of the beam forming the front edge of the dolphin. Fig. 36 is a section of the transverse beam forming the extreme northern end of the quay, while details of the reinforcement of the longitudinal beams carrying the crane tracks, and the intermediate longitudinal beams, are illustrated in Figs. 41 to 43.

Figs. 44 to 49 illustrate the construction of the special hollow piles above referred to as having been used for the front row of the quay. The method of attaching the steel shoe and the general arrangement of the reinforcement are clearly shown in the figures; but the most interesting feature is, of course, the hollow construction. The object of the hollow construction is to obtain a larger surface area, and consequently greater bearing power, for a given weight of concrete employed. The hollow space is formed by a series of thin steel tubes each 8 in. in diameter internally and 3 ft. 9 in. in length, the tubes being supported in the mould as shown in Figs. 47 and 48. The support consists of a casting comprising a double flanged tube with four radial projecting arms forming a spider and fitting on to the main reinforcing rods, as will be clear from Fig. 48. It will be readily understood that the spiders also serve to keep the main rods in position when the reinforcement is being made and placed in the mould before pouring, and it is also claimed that they serve to break up the vibrations due to driving. At the top and bottom ends of the

Fig. 44.

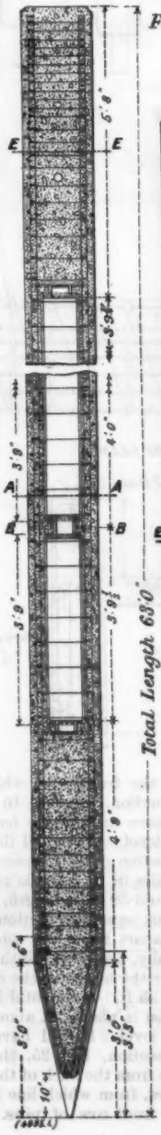


Fig. 45.
SECTION D.D.

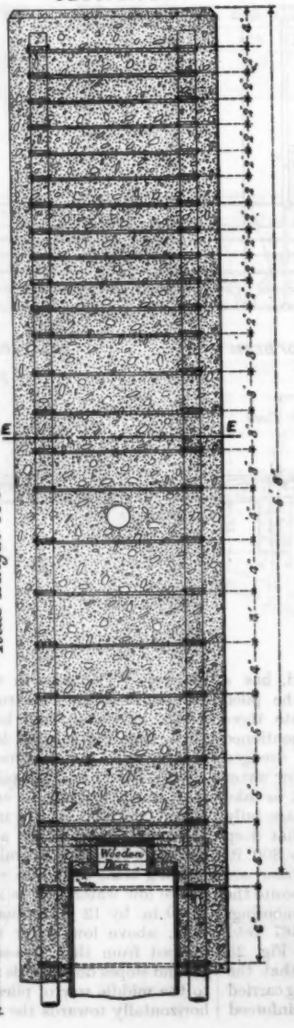


Fig. 46. SECTION E.E.

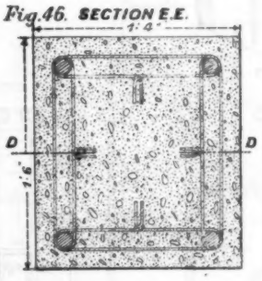


Fig. 47. SECTION C.C.

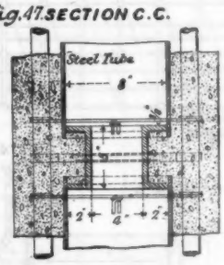


Fig. 48. SECTION B.B.

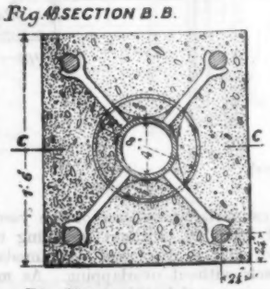
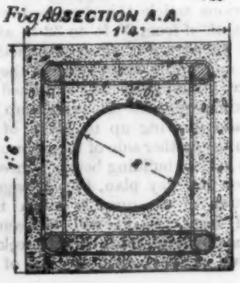
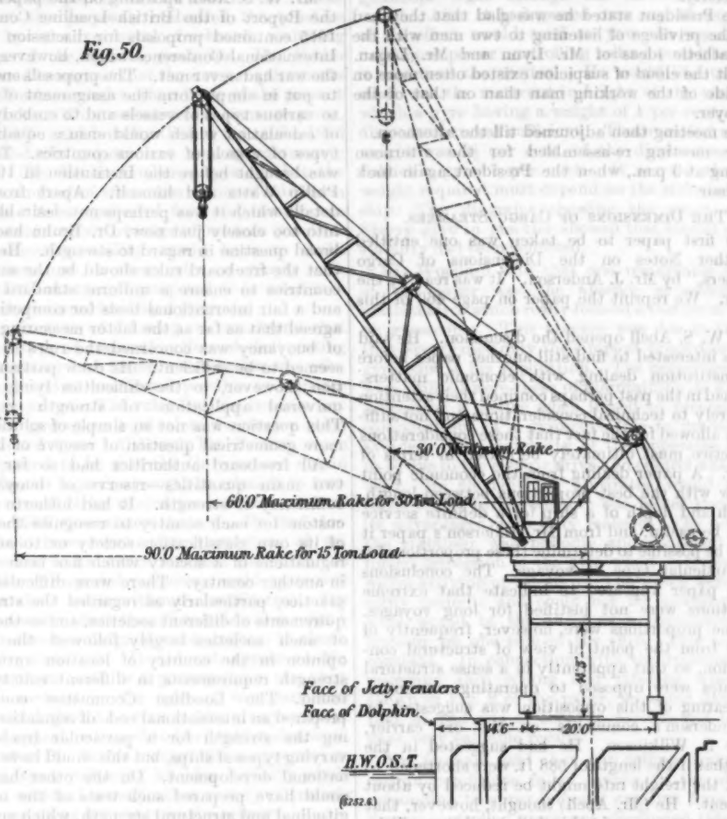


Fig. 49. SECTION A.A.



ARMSTRONG SHIPYARD; 30-TON LUFFING CRANE.

Fig. 50.



hollow space the spiders employed are of rather different design, as shown in Fig. 44, and the hole in the cast-iron tube is closed by means of a disc of wood to prevent the concrete from entering the opening.

The crane girders of the deck are designed to carry the 30-ton electric travelling luffing crane, an outline diagram of which is given in Fig. 50, annexed. The total weight of the crane structure, ballast and load, amounts to 175 tons, and is supported on eight wheels. The crane, which was built at Messrs. Armstrong's Elswick Works, is capable of lifting 30 tons at a maximum radius of 60 ft., and at a speed of 20 ft. per minute; but a 15 ton load can be lifted at any radius up to 90 ft. at the rate of 40 ft. per minute. The minimum radius for any load is 30 ft., and the travelling speed, with a 30 ton load, is 60 ft. per minute. The motors, which are of Messrs. Armstrong's manufacture, are of the totally enclosed reversible slip-ring type for three-phase currents at 440 volts pressure and 40 cycles per second periodicity. As previously mentioned, one of the travelling tower cranes is used on this quay; the luffing crane can travel along the whole length. A 5-ton travelling luffing crane is also provided, and at each end of the quay there are fixed Scotch derrick cranes; that at the northern end is electrically operated, and is capable of lifting 4 tons, while that at the southern end is steam driven, and can lift 7 tons. Two 12-ton electric warping winches and three 30-ton electric capstans are also employed on the quay. The contractors for the jetties between the building berths, the fitting-out quay and the piled roundhead were Messrs. Edmund Nuttall and Co., of Manchester.

(To be continued.)

DEVELOPMENT OF HANGÖ, FINLAND.—The Department of Overseas Trade has received information from the British Consulate at Helsingfors to the effect that a company, entitled the "Aktiebolaget Hangö Frihamn" has acquired on lease for a period of thirty years certain sites at Hangö port, which it is proposed to utilise in connection with harbour developments.

THE INSTITUTION OF NAVAL ARCHITECTS.

(Continued from page 420.)

THE spring meeting of the Institution of Naval Architects was continued on Thursday, the 25th inst., the chair again being taken by the Earl of Durham at 11 a.m. on that day.

THE ECONOMIC POSITION OF THE SHIPBUILDING INDUSTRY.

The paper taken at this morning's meeting was by Sir A. F. Yarrow, Bart., and was entitled "Notes on our Economic Position as a Shipbuilding Country." This we reprint elsewhere in this issue. In reading his paper, Sir A. F. Yarrow stated that he desired the discussion, if possible, to turn on the questions of personal intercourse and human sympathy between employers and employed, and this formed the subject of most of the subsequent speeches.

The discussion was opened by Professor W. E. Dalby, who said that they were all interested particularly in the question as to what prospect there was of prices falling. Many salaries were being paid at a pre-war basis, but had to be spent at post-war value. This was a natural cause of unrest. He wished to restrict his remarks to the relations between the craftsmen and principals. The unrest was deep-rooted and existed in the community before the war. They were in the state now of both masters and men being mobilised, and the two armies facing one another. The great national problem of the day was, how could we draw these two opposing forces together. All were too well aware of the separation that existed between the craftsman and the principal. They were, so to speak, divided by a wall through which they could only communicate one with the other through holes guarded by men who often misinterpreted the case of one of the other party. Many strikes were merely due to misunderstandings. He always considered that the old apprenticeship system did a good deal to encourage sympathetic consideration. Master—craftsmen and those employed worked side by side. In some of the older firms you could find workmen to the third generation in the shops; there were few strikes in such concerns. Under the Limited Liabilities Act the worker did not know who he worked for and was driven to combinations, in order to treat with those who actually employed him. He thought the more intercourse the better.

Mr. W. H. Whiting said the author had broken new ground for the Institution, which was ordinarily concerned with mechanical and scientific progress. Nothing, he thought, could do so much for shipping and our country as a whole-hearted concentration on industry at present. There was no doubt that there were mistaken ideas held in the industrial community which, unless faced and answered, threatened great danger to the future. They wanted maximum output, because that was the only means by which it was possible to raise the rate of remuneration in any trade. Payment by results was essential as was also the prompt utilisation of every invention and assistance possible to skilled and unskilled labour. There ought to be some means of rapidly readjusting rates, and there should be some permanent basis to go on. What was at the root of the workers' objections? They were, firstly, of the opinion that restriction of output increased employment; secondly, that high piece work output led to cutting rates; and, thirdly, that the use of machines tended to displace skilled labour. He did not think any really adequate answers had been given to these; the question had not been sufficiently thoroughly gone into for a correct reply to be given. The Government, he thought, as the only agency by which the parties might be drawn together, might call a conference or committee to get to the bottom of the matter.

Mr. Lynn, who followed, spoke as a shop steward, and asked what was really in the mind of the really thinking man in the workshops. The real trouble was that the working man was advancing, but could not get into touch with the employer to let him know how he was advancing. The workman needed to get into contact with the employer and tell him what he wanted before the row started. He hoped the paper would help in bringing to an end the era of disputes. The unthinking man had the idea that the employer did not care more about the man than the machine. He was in the shipbuilding industry, and chairman of a shop stewards' committee. He thought shop stewards as a body were the most unjustly dealt with body of men in industry. When anything went wrong the blame was placed on the shop-steward. He thought we were up against a critical period of the world. The industries of the State were in danger, and the position of the white races was in danger. The situation would not be saved by recourse to arms, but only by the employers and employees coming closer together. The one had hitherto regarded the workman too much as a means of making a profit, while the latter often regarded the employer as his chief enemy. The worker must be made to feel that the employer had a higher ideal for him. The Employers Federation on the one hand, and the trades unions on the other, as they existed now, were a hindrance. Both hampered healthy competition, which, he thought, should not be restricted. All unions of one class or the other should be used for the welfare of the worker and of the State. Shop committees should be encouraged to meet the employers, and at such meetings the shop managers and foremen should be present, and suggestions should be received and decided upon. He was not speaking as a delegate. The men had not had any invitation from the Institution; they were waiting for it. He had no time for men who believed in restriction of output. Many employers worked long hours. The workers did not realise that. That could be remedied by more intimate contact between the two. There was a sentiment growing in favour of direct action. He deplored any departure from constitutional methods, but there was something dangerously wrong with the workshops to-day. That must be rectified. The man from the mansion had fought by the side of the man from the slum in the trenches. Now the man from the slum wanted to make a bit of a stride and had a feeling that they should not be parted so far as they were now.

Colonel Smith Park took exception to one expres-

sion of the paper, which referred to those who worked for wages and a margin for old age. The workman resented the idea that he was only entitled to a wage and a margin for old age. He was entitled to a reasonable share of luxuries as well. If the spirit of the last speaker were more common there would be fewer strikes. He thought trouble was often brought about by the spirit of threatening. Employers in this country were embued with the same fighting spirit as other people, and when threats were used this naturally showed itself. Intimidation, as permitted under the Trades Disputes Act, was also responsible for many strikes. It gave the employers the idea that if the men were not intimidated they would be able to get labour at the price they wanted.

Mr. W. W. Mariner said that during the war finance was only one factor in many of the disputes. We took too sordid a view of human nature. Often advances were given during the war which were resented. The men did not require driving. At the present time, however much was offered, it was impossible to get a good cook or housemaid. Money was not the only incentive. In former times there was close personal contact between the worker and master. That was difficult now-a-days, but it was necessary to success. Thinking men revolted against the present system of industry. He wanted direct contact with the men, not through committees. Sir A. Yarrow had always maintained that in his works at Poplar, walking through the shops constantly and talking with the men. He had there known personally about 500 of his employees. Nothing paid so well as giving each day some time to speaking to individual men, without the intermediaries of shop foremen, stewards or supervisors. That was more important than the introduction of up-to-date machines.

M. W. H. Martin (Flushing) said the gap between the two sides grew bigger as factories grew larger. In the British factory system the employers and employees seldom came into contact. In the German factory a kind of military discipline was maintained, and the men were almost reduced to the condition of slaves, but the employers did a great deal for the welfare of their men. In Holland they had a mean between the two. The principals made a point of spending some of their time in contact with the men in the shops, and also were in the habit of meeting deputations selected by the men. The speaker's father at the Flushing yard used to go into the shops daily and also remained in his office a quarter of an hour after the lunch hour bell had gone, when he was in the habit of receiving any workman who wished to consult him, as they did on all sorts of subjects. That quarter-of-an-hour did an immense amount of good, and during his 43 years of control, nothing had been heard of strikes. He thought a great deal could be done by the provision of cheap cottages and gardens, which could be purchased after some time on easy terms. In their schools much more science was required than appeared to be the case here.

The next speaker drew attention to the fact that the figures of national expenditure given in the paper were not up-to-date, after which the President called upon Mr. Logan (shop steward). Mr. Logan said he thought it a sign of the times that we had shop stewards, for they were elected men, with responsibilities. The securing of goodwill was most important. They should explore every source by which the industry could be maintained. Under such an era of goodwill he hoped strikes would be eliminated. They were the greatest hindrance to progress. Most could be avoided if the parties could meet at the outset, as they were compelled invariably to do at the finish. What was the use of making working men more intelligent if they were going to restrict him afterwards? Education had embued men with other feelings than those relating merely to their hourly wage. They wanted to feel that they were responsible men. Would increased production be secured? The workman turned it down because he was suffering from the heritage of past misunderstanding.

Sir A. Yarrow, in reply to the discussion, said he thought only those who had themselves worked sometime in the shops and who had subsequently become employers, could get a thorough knowledge of both sides. A knowledge of human nature was more important than a knowledge of the intricacies of a machine tool, or a mathematical tripos at the University.

The President stated he was glad that they had had the privilege of listening to two men with the sympathetic ideas of Mr. Lynn and Mr. Logan. He felt the cloud of suspicion existed often more on the side of the working man than on that of the employer.

The meeting then adjourned till the afternoon.

The meeting re-assembled for the afternoon meeting at 3 p.m., when the President again took the chair

The Dimensions of Cargo Steamers.

The first paper to be taken was one entitled "Further Notes on the Dimensions of Cargo Steamers," by Mr. J. Anderson. It was read by the author. We reprint the paper on page 460 of this issue.

Mr. W. S. Abell opened the discussion. He said he was interested to find still another paper before the Institution dealing with economic matters. They had in the past perhaps confined their attention too purely to technical considerations and not sufficiently allowed for the fact that these considerations in practice must ultimately be stated in terms of money. A paper dealing from the economic point of view with the best proportions between length, breadth and depth of a ship for a definite service should be useful, and from Mr. Anderson's paper it should be possible to determine these proportions for any particular type of voyage. The conclusions of the paper appeared to indicate that extreme proportions were not justified for long voyages. Extreme proportions were, however, frequently of service from the point of view of structural consideration, so that apparently in a sense structural economics were opposed to operating economics. The bearing of this opposition was suggested by Mr. Anderson's comments on the ore carrier, Horace S. Wilkinson. He had suggested in the paper that if the length of 588 ft. were shortened to 430 ft., the freight rate might be reduced by about 5 per cent. He (Mr. Abell) thought, however, that if the case were examined in full detail it would be found that considerations came in which were not allowed for in the general case considered in the paper. In conclusion, he would be glad if the author would say something about the form of vessel and block coefficient he had used in his calculations.

Professor J. J. Welch was the only other speaker on the paper. He said its compilation must have necessitated a very large amount of work, and as the considerations it brought forward were of direct interest to the shipowner and superintendent-engineer he hoped they would study it. The subject was one that had been given a good deal of attention in the past, and he would ask the author if he had studied earlier papers, and, if so, did they point to the same conclusions as his own. He would also like to know if the conclusions following from the analysis in the paper corresponded at all nearly with what was found to be done in general practice, or did they suggest departures from such practice. He took it that the curves and tables of the paper were not intended to be slavishly followed, but that they were mainly intended to indicate a method of tackling the problem.

Mr. Anderson then replied. He said that the ship form he used had followed fairly general practice. The block coefficient was about ·77. In reply to Professor Welch it was difficult to say how the results given by the paper compared with actual practice, as it was almost impossible to get exact data about the loading speeds of various ships. It was common knowledge, however, that extreme proportions were very common on short-run ships, coasters, &c. In these cases there was usually extra hatch accommodation and special handling arrangements.

Freeboard and Strength of Ships.

The next paper was one by Mr. J. Bruhn entitled "Freeboard and Strength of Ships." In the absence of the author the paper was taken as read. The paper, which we hope to reprint later, covered an examination of the present rules and practices of various countries in regard to rules for freeboard and strength, and considerations towards the achievement of international rules. Some features of the paper are indicated in the report of the discussion which follows.

Mr. W. S. Abell speaking on the paper said that the Report of the British Loadline Committee of 1915 contained proposals for discussion before an International Conference which, however, owing to the war had never met. The proposals endeavoured to put in simple form the assignment of freeboard to various types of vessels and to embody methods of calculation which would ensure equality for all types of vessels of various countries. The matter was brought before the Institution in 1911 by Sir Philip Watts and himself. Apart from certain details which it was perhaps not desirable to enter into too closely just now, Dr. Bruhn had raised a broad question in regard to strength. He observed that the freeboard rules should be the same for all countries to ensure a uniform standard of safety and a fair international basis for competition. He agreed that as far as the factor measuring a reserve of buoyancy was concerned the rules as proposed seemed to be sufficient. He drew particular attention, however, to the difficulties lying behind a universal application of strength regulations. This question was not so simple of solution as the more geometrical question of reserve of buoyancy.

All freeboard authorities had so far specified two main quantities—reserve of buoyancy and sufficiency of strength. It had hitherto been the custom for each country to recognise the practice of its own classification society or to accept the regulations of a society which has been approved in another country. There were difficulties in this practice, particularly as regarded the strength requirements of different societies, and as the practice of such societies largely followed the trend of opinion in the country of location variations in strength requirements in different countries were found. The Loadline Committee could have prepared an international code of regulations assigning the strength for a particular freeboard for varying types of ships, but this would have hindered national development. On the other hand, they could have prepared such tests of the main longitudinal and structural strength, which any nation signatory to the Freeboard Convention could apply to a proposed standard of strength and which would enable an international body to judge from a sense of proportion whatever proposed rules were equivalent to the general standard. As Dr. Bruhn said (but it applied almost entirely to local strength) the Committees Report did not take account of the whole problem, but if the modulus of resistance of the main structure in association with the draught was satisfied, if the requirements as regards strength of main frames was satisfied, if the frame spacing and thickness of side plating were fixed and other features were in consonance, the way was paved for acceptance of any standard which might be put forward for international recognition.

It might be that when an international conference did meet, there might be some desire for more tests to be added, such in particular as Dr. Bruhn suggested for strength of decks. There did not appear to be great difficulty in this, but the fewer and broader the tests the easier would it be to obtain international agreement. Dr. Bruhn appeared to confuse the tests for the strength of ships with scantling requirements, and appeared to indicate that the adoption of those tests would establish a second system of determining scantlings in addition to the Classification Societies' requirements. He suggested that if such a method was established internationally it would hinder progress. These tests should, however, be looked upon as measures of maximum permissible stress allowed for longitudinal bending moment and transverse strain. There was no reason why they should be altered until some new material, say, 27–32-ton steel was used for the construction of ships.

To turn to some of the criticism of detail in Dr. Bruhn's paper, he appeared to suggest that the scantlings required for Norwegian ships were in excess of those required for other countries. This might be because Norway was practically unique in her freeboard rules, and it certainly seemed that the sooner she came into line with other countries the better for herself. Dr. Bruhn appeared to suggest that the proposals of the Loadline Com-

mittee were the best possible for British conditions. In the previous papers he had referred to it was stated that the proposals embodied the practice followed by the principal freeboard assigning authorities of the various countries. Dr. Bruhn also appeared to suggest that the stress requirements of the 1885 rules were less than those of the present Lloyd's Rules. This was true in some respects, but it could be said broadly that as far as the 1885 rules applied the requirement was approximately the same. Dr. Bruhn further suggested that the proposed standard of stress was a sort of minimum of minima. As a matter of fact an attempt was made to obtain a fair average of modern practice. Any classification society would have to make certain alterations in their rules to comply with the standards of strength proposed to be used as a test for international freeboard purposes.

On the question of framing, it was found that for a given type of frame the effect of shell plating when comparing one frame with another was relatively small and it was found possible to legislate for framing *per se*. The rules did not contain any method for giving an equivalent frame for other than standard type. Although Dr. Bruhn's main claim appeared to be that the Government should not interfere as regards strength in relation to freeboard, yet in effect his contention was more narrow than the 1915 Committee desired. He had forgotten that there were a fair proportion of unclassed vessels in existence and that these, built in many cases for special purposes, could quite well carry out their work without classification. His contention was in effect that all vessels which require to have freeboards assigned must conform to classification requirements. It did not appear to Mr. Abell that there could be any compulsion of a shipowner to conform to the rules of any particular society, and it should be open to him always to have a court of appeal, in regard to freeboard assignment, which under Dr. Bruhn's suggestions appeared to be closed, since following his idea logically would make the national classification society ultimately the only assigning authority in the country.

Mr. Benson Taylor was the only other speaker on this paper. He said Mr. Abell has so fully covered the ground that there was little left for him to say. He would like to state, however, that he thought the report of the Loadline Committee had been used in a way for which it was never intended. He was not at all sure that naval architects would like the Government to introduce a set of rules.

A Gyroscopic Stabiliser.

The next paper was one entitled "The Stabilisation of Ships by Means of Gyroscopes." It was read by the author, Mr. P. R. Jackson. The paper will be found reprinted on page 462 of this issue.

Mr. Sydney Barnaby was the first speaker in the discussion. He said that, apart from anti-rolling tanks, three methods of steadying a ship at sea had now been brought before the Institution. The first was that due to Sir John I. Thornycroft (the paper was read at the 1892 meeting of the Institution). The Thornycroft apparatus was applied to a yacht which was not very suitable for purposes of experiment as she was unusually stable. The apparatus consisted of a weight which could swing round a vertical spindle. The boat was so stable that when the weight was swung round to the full extent she only inclined 2 deg. in still water. The operation of the weight did not depend on the roll of the ship, but depended on the movement of translation of the water under the ship and so anticipated the roll. The second method of stabilising which had been brought before the Institution was that due to Schlick, whose paper was read in 1904. The apparatus consisted of a gyroscope with its spindle vertical and free to oscillate in a fore and aft plane. If the spindle was locked the gyroscope had no effect on the rolling, but if it was free to oscillate it generated a couple opposing the roll. The horizontal spindle was controlled by water brakes.

At first sight Mr. Barnaby said it was not clear in what the difference between the Schlick system and the Sperry lay, but actually there was a great difference. In the Sperry device the gyro wheel was actively moved. It was pushed on by the motor which operated from the control gyro and so anticipated the rolling. He was not clear why it was necessary to maintain the movement of the gyroscope right through the movement of the vessel. After it had moved over say 45 deg. part of its effect would tend to yaw the vessel. Its maximum power controlling rolling would be when it was near the vertical. He would like to know what was the metacentric height of the vessel for which a gyro having a weight of 1 per cent. of the displacement was sufficient. Thornycrofts' moving weight was 3½ per cent. of the displacement and Schlick's gyro 7 per cent. It seemed that the weight required must depend on the stiffness of the ship. The diagrams showing the effect of the Sperry gyro in practice showed that almost perfect stability had been achieved.

Mr. Woollard said that one remarkable feature of the paper was the absence of complicated mathematics which really formed a feature of papers on gyroscopes. This absence was due to the fact that Sperry used only the simplest properties of the gyroscope in his application. The properties which were utilised were those of maintaining its axis and generating a couple when forced to precess. The complications of a gyroscope free to precess were avoided. The simplicity of the apparatus seemed to be due to the electric drive and control which were used. He thought the apparatus would have a considerable future when it was better known and its advantages were fully realised. The action of the stabiliser was periodic and depended on the forced precession of the gyro wheel in terms of the waves arriving at the ship. The waves were necessarily periodic and could not be continuous, but what would be the effect of a continuous wind pressure on one side of the ship. This might be constant. In connection with the instrument for recording ship rolling and pitching which was shown in Fig. 2 of the paper, he would like to say that he had one of these in service and found it gave very valuable results.

Mr. Graham said that anti-rolling tanks under certain conditions failed, owing to the ship not responding to super-imposed external forces. The Sperry controlled gyroscope eliminated this defect. The recording instrument described was a very useful instrument. One had been fitted on the Imperator on her last voyage, and almost every conceivable external force which acted on the ship was recorded. In connection with the stabilizer, he admitted that a non-rolling ship was better than a rolling one, but he thought the pitching was perhaps more trouble than the rolling. It was the pitching that interfered with steering. The Sperry gyroscope would be an expensive item in a big ship, and nowadays with costs up to such an extent, this had become a very important matter. With a 28,000-ton ship, the wheel would weigh 280 tons, and would be a large fitment. The annual rental on such an installation might amount to £3,000, to £4,000 a year. None the less it would certainly be of great value in passenger ships. Anyone who had slept in the wing cabin of the Aquatania, with its drop of 25 ft. or so, would appreciate this. The trouble was that one could not now afford to build purely passenger ships. The apparatus would be a great advantage, but the question of cost was a serious one.

Mr. Jackson then replied to the discussion. He said the particular features of the Sperry gyroscope were that the gyrostatic inertia was overcome and the precession was controlled. The maximum controlling effect of the wheel was when it stood vertical, if it moved round through 90 deg. it would have no effect on the ship at all. The movement was limited to 60 deg. because beyond 60 deg. or 70 deg. the controlling effect was so small as to be useless. The metacentric height for the gyro weight of 1 per cent. was about 2½ ft. This was usual for large passenger ships. With battleships and train ferries one met with difficulties as the metacentric height might rise to 4 ft. or 5 ft. He had known it as great as 9 ft. in a train ferry. The question of wind list referred to by Mr. Woollard would not affect the action of the gyro at all. The gyro did not act in terms of list, but in terms of an applied acceleration. It applied a couple to the ship at pre-determined times. If there was a wind list the gyro would simply stabilise the ship in her new position. In connection with Mr. Graham's remarks he would say that it was impossible to eliminate pitching. The amplitude of pitching was, however, rarely bad, and it was chiefly by rolling that damage was done. The installation would certainly not be a cheap one, but the present high prices were simply a reason for getting every ounce out of a costly thing like a ship. The question of the elimination of the bilge keel and the fact that on even keel this had a resistance of 4 per cent. was great argument for installing stabilising gear. He thought even Mr. Graham's 3,000*l.* a year on a large ship would be well spent.

The Yawing of Ships.

The final paper at the morning session was one entitled "Yawing of Ships Caused by Oscillations Amongst Waves," by Dr. K. Suyehiro. In the absence of the author the paper was taken as read. We hope to reprint it later. It concerned an investigation of the cause of a boat riding freely among waves setting itself parallel to the wave crests in some cases and perpendicular to them in others.

Sir George Greenhill was the only speaker on the paper. He congratulated the author on the elegance of his mathematics, and would ask if his investigation could not be extended to the case, well-known to fishermen, of a boat capsizing on the crest of a wave. This phenomena was usually confined to small craft, but it happened on a larger scale during the laying of the first Atlantic cable.

The meeting then adjourned.

Effect of Size upon Performance of Rigid Airships.

On reassembling in the evening, in the absence of the president the chair was occupied by Sir Eustace d'Eyncourt, and the first paper taken was that by Mr. C. I. R. Campbell and Mr. H. May, bearing the above title. On page 464 we publish in full the text and illustrations of this paper, which was read in abstract by Mr. May, so that we may at once proceed to the discussion. Colonel T. R. Cave-Brown-Cave, the first speaker, said he thought the paper contained an immense amount of useful information, but, in his opinion, its most valuable feature was the particularly clear discussion of the way in which the weights of the parts varied with the size of the airship. The only part with which he was not in agreement was the statement made that the air pressures per unit area on the fins, &c., were equal for ships of different sizes; he thought this pressure would be found to vary. A large ship would be less affected by atmospheric disturbances and the air speed relatively to the fin surface would be higher. He also thought that one or two other items might with advantage have been included in the table given towards the end of the paper. The dynamic lift, for instance, would vary as N^3 and the false lift, due to superheating of the gas, as N^3. In the larger ship it would not be so easy to overcome the false lift by inclining. With regard to the extent to which a ship would be thrown about by atmospheric disturbances he said the moment of the forces exerted would vary as N^3 and, as the moment of inertia varied as N^5, the angular acceleration would be inversely proportional to N^2. This would give greater comfort to the passengers in larger ships. The table given in the paper was very interesting, but he thought the deductions would be clearer if actual coefficients of each term had been given. The authors had grouped all the N^3 terms and given coefficients of each group, but the speaker thought it would have been more informing if each item in the group had been given separately. The chief offenders in the case of large airships were the terms in N^4, but these he thought would be greatly affected by improvements in the design of the larger ships. In going from a ship of 5,000,000 cub. ft. to 15,000,000 cub. ft. capacity considerable improvements would undoubtedly be effected in design and estimates of performance based on the assumption of no improvement were extremely pessimistic. The formulæ in the paper were based on a type ship of 3,000,000 cub. ft. capacity, and the deductions made referred to ships of from 5,000,000 cub. ft. to 15,000,000 cub. ft. The law of similarity, the speaker said, was a doubtful business at the best, and in this case he thought the extrapolation extremely risky. To show how

improvements in design affected comparisons of different vessels the speaker gave some data relating to German airships taking the L 33 as the type ship. In this ship, which had a capacity of 2,000,000 cub. ft., the ratio of disposable to gross lift was 33 per cent., whereas in the L 66, which had the same capacity, the corresponding figure was 58 per cent., and the speed was 5 knots higher. In the L 70, with a capacity of 2,750,000 cub. ft., the ratio was 60 per cent. and the speed 15 knots higher than that of the type ship. In the later, but very much smaller, airship, the Bodensee, having a capacity of only 750,000 cub. ft., the ratio of disposable to gross lift was 35 per cent. and the speed 20 knots higher than the L 33. He therefore thought that the results set out in the paper were much too modest in their claims for the large ship.

Mr. W. H. Whiting, the next speaker, said his only connection with airship construction was with the Mayfly, but he took considerable interest in airship performances. In the paper he noticed the statement that the diagonal wiring must be assumed to take practically the whole of the shear and torsional stresses, and he wished to inquire whether means had yet been devised for determining the stresses in these wires by mechanical means.

Major Pritchard, who followed, said he considered Messrs. Campbell and May's paper one of very great value, but its most marked feature was its restraint, not to say pessimism. The large airships referred to, he thought, would never have performances so low as those predicted in the paper. Rigid airships of 5,000,000 cub. ft. to 15,000,000 cub. ft. capacity were a long way ahead, but by the time they were built improvements in design would give greatly improved performances. At the same time, it was desirable that size should be increased gradually. Airships were to-day in much the same position as heavier-than-air machines were before the war, and a paper had been read some years ago to prove that an aeroplane of more than a certain size could not lift itself off the ground. Actually much larger machines had now been built with a ratio of disposable to gross lift of 40 per cent.

The last speaker in the discussion was Commander E. Land, of the United States Navy, who said he owed much to the authors for their application of the law of similitude to rigid airship design. The law held closely in certain branches of work and, if the same principles applied to rigid airships, he thought the authors had gone a long way to establish a basis for future design. He thought it always better to err, if at all, on the side of undue pessimism, as the authors had done, as this was less likely to lead to disappointment. He thought the statement in the paper that the scantlings of the intermediate longitudinals were settled by judgment rather than by calculation and that their weight varied as N^3 required some further elucidation, as also did the statement that the resistance of appendages varied as N^3. He also wished to inquire whether the coefficients used would be altered if some other materials were discovered to take the places of gold-beaters' skin and duralumin. The paper would, he thought, have been more convincing if the authors had stated whether existing ships followed the law of similitude.

Mr. Campbell then replied to the discussion. So many very interesting points, he said, had been raised, that it was not possible for him to reply to them all. With regard to Colonel Cave-Brown-Cave's remark that the fin-loading was not constant, but would be greater in large ships, this might be correct, but he would point out that large ships were less likely to swing off their courses, so that their fins would be less exposed to air currents. Large ships would certainly be steadier and more comfortable, and this was emphasised by the fact that air bumps were not large in area, so that they would affect a large ship less than a small one. It was quite correct that the heating effect could be less readily corrected by inclining in a large ship than in a small one, but he hoped that, before very large ships were constructed, it would be possible to reduce the importance of the heating effect; if not, additional fins would have to be provided. With regard to giving actual coefficients for ships in the table, this, he said, would be difficult to do, as the data available referred to rather old ships and might be misleading. Most of the speakers in the discussion had regarded him as pessimistic, and this might be correct, but, after years of experience in design, one tended to become so. Pilots were constantly requiring additional fittings and other weights were always being added, so that designers thought they were doing well if they could save enough weight on other parts of the ship to enable these requirements to be met. As stated in the early part of the paper, however, the curves must not be taken too literally, as vessels of increased size might differ considerably from the type ship. The main point to be brought out was that there was considerable gain in going to larger sizes. In reply to Mr. Whiting, he said that they could easily determine the tension in wires by mechanical means. Commander Land, the speaker continued, had certainly touched them in pointing out that their judgment apparently varied as N^5. What they should have said was that, for want of better information, they had fallen back on ordinary structural considerations. The resistance of hull and appendages had been taken as following the same law, but there was no exact law for the appendages. The machinery cars would be similar if for the same power so that the number of cars would vary as N^3 and the resistance also varied as N^3 and with regard to the planes, to assume that their resistances varied in the same way, was as near as they could go. If a substitute were found for gold-beaters' skin and duralumin it would certainly alter the coefficients, but at present they had nothing better in sight. With regard to the figures given by Colonel Cave-Brown-Cave for German airships, the speaker thought they were hardly applicable as the airships referred to were of very different types. The curves given in the paper, he thought, showed that airships of large sizes were quite practicable.

The Chairman, in congratulating the authors on their paper, said it was not always recognised how much pioneer work had been done on rigid airship design. The problems involved had all been new and designers had had nothing to go upon, but thanks to Messrs. Campbell and May and their colleagues useful data were now available. The question of cost had not been touched upon, but this was an important consideration in commercial enterprises. He would like to inquire whether steel or wood could be employed in place of the expensive aluminium. As head of the Royal Corps of Naval Constructors, he would like to express the regret felt by the Corps at the transference of Mr. Campbell to the Air Ministry, and, in conclusion, he asked the meeting to pass a vote of thanks to the authors for their excellent paper. Replying, Mr. Campbell said, with regard to the question of cost, it would be greatly reduced if steel could be employed, and this could probably be done in the larger ships.

The Effects of Holes, Cracks and other Discontinuities in Ships' Plating.

A paper with the above title by Professor E. G. Coker and Mr. A. L. Kimball, Jun., was then read by the latter. This paper, which will be reprinted in a later issue, deals with the stress distribution round an elliptical hole in a tension member as determined by optical methods with which our readers are familiar. A crack is considered as the limiting case of an ellipse in which the minor axis is vanishingly small, and it is easy to show experimentally, and by calculation, that stresses approaching an infinite value are produced at the ends of a crack when it is inclined to the direction of the stress. Methods of relieving the stress concentration by forming circular or elliptical holes at the ends of the crack, are discussed, and the stress distribution in the neighbourhood of a hatchway opening in a ship's deck is also considered.

Mr. C. E. Stromeyer, who was the only speaker on this paper, said the authors' results were very interesting, but with regard to cracks, he would prefer to see experiments made with actual cracks rather than with narrow slits. Personally, he would like to see the infinite stresses supposed to exist in the neighbourhood of cracks. He was much less afraid of these defects than formerly. The authors' experiments in connection with the holes and other openings in ships' decks were, however, extremely important and would doubtless lead to allowances being made for the increased stresses near the corners and for reductions in the scantlings at other parts. Seeing that the stresses at the corners of hatch holes are severe, he thought that they might be reduced by making the coamings continuous as this would strengthen the ship considerably.

Professor Coker, in replying, said, with regard to cracks, that if drilled out at the ends, they were less likely to spread, and in the cases they had examined, it was advantageous to employ elliptical holes if the minor axis of the ellipse were placed in the right position. In the model used for their experiments the ends of the crack had been formed by a $\frac{1}{32}$-in. drill, the smallest available, and, though it might have been possible to make a narrower slit, the stresses were then likely to exceed the elastic limit of the material, so that no measurements could be made. With regard to deck construction, he could not say what alterations should be made, as naval architecture was not his subject.

In thanking the authors for their paper, the Chairman said the strength of a ship's deck at the sides was made sufficient to reduce the stresses in way of the hatches, so that no tearing took place. He thought the illustrations and deductions in the paper were very suggestive, and they showed what should be done. If, however, a crack occurred in the bottom plating, it could not be remedied by boring holes. He mentioned a case in which a single butt strap had been insufficient to stop a crack, although the stress in the plate was only about 6 tons per square inch. Double butt straps had to be employed, or the crack stopped by arc welding.

After passing a vote of thanks to the authors for their paper, the meeting adjourned until the following morning.

(To be continued.)

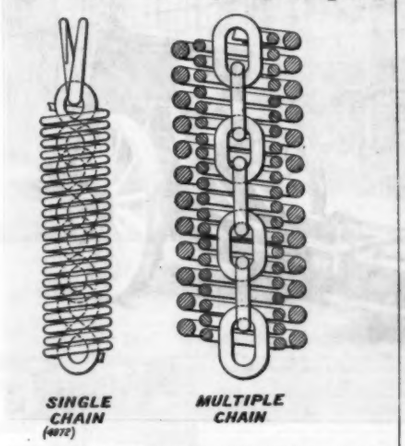
Water Power and Fuel in American Power Plants.—The Division of Power Resources, United States Geological Survey, says *Engineering News Record*, New York, has published figures showing the production of electric power by the public utility plants of the United States. The report, covering February, March and April, 1919, was based on returns from about 3,100 electric power plants engaged in public service, and including central stations, electric railway and certain other plants whose output contributed to the public supply. The statistics show the relative output from plants operated by fuel and by water power. In February, nearly 39 per cent. of the total was produced by water power; in March it had increased to 42 per cent., and in April to 43 per cent. The average monthly consumption of coal by public-service plants during the period was 2,815,000 tons, or 95,000 tons per day. Of that coal consumption 39 per cent. was in New England, New York, New Jersey and Pennsylvania. In addition to the coal used to produce about 59 per cent. of all public service electric power, there was also consumed a monthly average of 668,853 barrels of petroleum or its derivatives, and 1,703,788 cub. ft. of natural gas.

Queensland's Mineral Wealth.—The Royal Commission on State Iron and Steel Works, appointed by the Queensland Government to inquire into the location, quantities, and suitableness of iron ore deposits and fuel supplies, the most suitable site for State iron and steel works, and the cost of equipping such works, presented a progress report in which they pointed out that the site for a central works could only be determined after locating the largest and most suitable deposits of ore, coal, fluxes, &c., and they subsequently recommended that the selection of the site be left in the hands of an expert. The Commission discovered that there were 500,000 tons of magnetite iron ore at Mount Biggenden. The wonderful purity of the ore was vouched for by the geological staff, and it only needed the construction of a tramway to utilise the large deposits then known to exist. The short distance from port was also pointed out as a factor in favour of the development of the iron ores there. Since then the enormous resources of the Bowen coalfield have been geologically proved, and boring operations have shown the existence of many millions of tons of good, payable coal. The large deposits of iron at Mount Leviathan—Mount Philp and Mount Biggenden have also since been reported on. The Mount Biggenden ore, however, is so unique in quality that it will pay the Government to work that mine, no matter where the works are established, but it cannot be worked without a tram-line. Both Mr. B. Dunstan, chief geologist, and Mr. L. C. Ball, of the Government Geological Staff, estimated that there were 500,000 tons of iron ore at Mount Biggenden, and the boring operations continued there have confirmed that estimate. The first bore and second bore confirmed the results obtained previously, and proved deposits at lower levels. The third bore, however, met with obstructions, and was abandoned, but it will be necessary to undertake further boring to discover further deposits. The iron ore at Mount Biggenden is of a high quality, of uniform texture and value, and is very clean.

THE CHAINE HELICE.

THE "Chaine Helice" liquid elevator formed the subject of a paper read before the Junior Institution of Engineers on the 12th inst., by Mr. F. A. Simpson. This appliance, which to our knowledge was first exhibited in this country at the Royal Agricultural Show of 1914, was described briefly at the time in our columns.* Mr. Simpson's paper described the action of this device and discussed its application. The Chaine Helice, in its present form, was developed by M. Bessenet Favre, the early type being a simple hemp rope wound round with a spiral wire. As is well known the present pattern consists of an endless chain, with sections of double open-wound wire helix arranged at short intervals over its entire length, as illustrated below. This chain passes over a driving pulley at the top, and at the lower end is weighted by a heavy flanged pulley which rests in the loop of the chain keeping it taut. This pulley should be submerged to the extent of about 2 ft. if possible.

Experiments have shown that the best results with clear water have been obtained with the chain running at a speed of from 400 ft. to 700 ft. per minute, according to the size of the chain. The capacity of the pump is affected by the height, the viscosity of the liquid, &c. The chain dips into the fluid in the well or container, the spirals become charged, and the fluid is carried up until the chain reaches the upper pulley, where it is discharged by centrifugal force into a receiver. In dealing with heavy liquids additional means are provided for removing the liquid from the outside of the chain, as centrifugal action is insufficient in this case alone. The losses on the upward path are mainly



due to the slip of the fluid in relation to the chain. As, however, in falling, the fluid is constantly coming against the spirals of the chain, no great momentum is obtained, the mechanical efficiency of the device running out at about 50 per cent. It is calculated that between 70 and 80 per cent. of the water raised by the chain is delivered.

When in motion there is a tendency for the chain to wind, owing to the action of the spirals over the driving pulley. This is circumvented by introducing a swivel link in each chain, the standard chain length being 5 ft. Two sizes of chain are manufactured, viz., 31 mm. and 43 mm. With the latter size, which is a double spiral chain, and 3 ft. submersion and 30 ft. lift, a 1-h.p. engine driving a chaine helice will deliver about 2,250 gallons per hour. With a 200-ft. lift a 5-h.p. plant will be required, and the delivery will be only slightly less, viz., 2,140 gallons per hour. With the single spiral, 31-mm. chain, the capacity ranges between 1,200 gallons and 1,150 gallons per hour, according to the lift, between 30 ft. and 200 ft., the horse-power needed ranging between 0·7 for the lower lift to 3·2 for the higher. Smaller pumps for hand operation deliver up to 150 gallons for 165-ft. lift.

As is known, this device was extensively adopted by the British Expeditionary Forces in France, Palestine, &c., something like 20,000 being in use in France alone. It may be mentioned that it can be effectively used for clearing a well or trench if the bottom is sufficiently loose for the chain to score a groove in it without risk of the counterweight pulley becoming detached. A practical point in its application to deep well work is that all the work of installation is above ground, there being no fixtures down the well shaft, so that descent of the well is unnecessary. The installation of a unit is a matter of only one or two hours' work if a suitable platform at the well head is available. There are very few parts to get out of order, and the life of all parts is very good. The initial cost is about half that of other types of pumps. The upkeep is small, and the life a good deal longer than ordinary rotary or plunger pumps.

It may be interesting to supplement the above summary of Mr. Simpson's paper by stating that in South America we understand even a simpler type of liquid elevator is in use, consisting of a simple link chain run at high speed. Probably the efficiency is rather below that of the spiral links. It is also interesting to record that in France latterly a canvas belt was largely substituted for the chaine helice in the British armies and gave very good results under many conditions.

* See ENGINEERING, vol. xcviii, p. 40.

AN ELECTRIC RIVET HEATER.

THE question of heating rivets electrically is, as far as we know, one to which no great amount of attention has been paid in this country, although the system has had some application in America. In approaching the matter we do not pretend to say how, in normal practice, the cost of electrically heating rivets will compare with the corresponding cost using coke fires, but the electrical method can claim several advantages which make it worthy of serious consideration, and it is possible it might make a good case on costs. This applies particularly to the resistance method as utilised in the machine which has been brought out by the Westminster Engineering Company, Limited, of

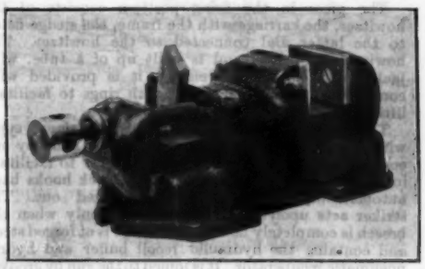
Victoria-road, Willesden Junction, N.W. 10, and which is illustrated above. The machine is a very simple one, consisting in brief of a transformer enclosed in a case carrying at the top a pair of spring-adjusted copper jaws. The jaws are connected in the secondary circuit of the transformer and the rivet to be heated, which is held between them, completes that circuit. The passage of the current through the rivet heats it up.

The current is only passing when the rivet is in place, the circuit being broken on the primary at each change. There are as a consequence no stand-by losses, resulting in economy in current consumption. A further point of considerable practical importance is that the greatest heat is produced inside the body of the rivet, with the result that the surface being the coolest part there is less scaling than when rivets are heated in a fire. Another feature of the machine is that the greatest heat is generated at the point of the rivet which is to be jumped up. The whole body quickly gets red, but the point is always a little hotter. This is evidently due to the effect of the resistance of the contact between the rivet and the copper jaw. The same effect is not apparent at the other end of the rivet, owing to the greater mass of the head demanding more heat for a corresponding rise in temperature. The machine operates very quickly, and when we saw it in operation and the whole appliance starting from cold a ¾-in. rivet, 3 in. long, was heated to a higher temperature than was really desirable for most work in something under 20 seconds. In normal operation the makers state ¾ in. diameter, 2¼-in. long rivets, with a 23 k.v.a. plant can be brought to riveting heat in 10 seconds. One British thermal unit will heat 19 such rivets, which at 1*d.* per unit works out at 5½*d.* for the heating of 100 rivets of this size.

The arrangement of the machine is quite simple, and will almost be understood from the illustration. All operations are controlled by a single lever. Between and below the spring-controlled copper jaws there is a small steel cradle on which a rivet to be heated is placed. The lever is then moved forward, when one of the jaws advances and grips the rivet endwise. Still advancing the lever causes the cradle to sink out of the way and at the same time causes the primary switch to make circuit. The rivet is then immediately heated up, and in 10 seconds or so the lever can be reversed. This first breaks the primary circuit and then raises the cradle so that it supports the heated rivet. Further movement of the lever then causes the jaws to release, and the rivet may be picked up by tongs and removed. The main switch with its connection to the lever can be seen on the side of the case in the illustration. It may, of course, be protected by a cover. The machine is mounted on small wheels to make it portable, and it will be clear that the whole arrangement is a simple one and not likely to get out of order. It should be of considerable convenience in many situations, and may possibly find a special field just now owing to the shortage and cost of coke. Electrical energy is one of the engineering commodities which have shown the smallest rises in price.

MACHINE VICE FOR REPETITION WORK.

THE Tangent Tool Company, Limited, of Keynsham, Somerset, have put on the market a design of machine vice which is particularly handy for quick operation repetition work, when similar articles have to be fixed and removed at short intervals. The vice is illustrated in the view annexed. The back jaw of the vice is the movable one, contrary to the usual practice, and this jaw is solid with a long slide, the front end of which carries the looking screw. The fixed jaw forms a cover to keep the slide in position, and on the end of the jaw



casting is hinged a steel plate, shown raised in the illustration. When raised, this plate uncovers a hole running through the jaw, and as the hole is larger than the diameter of the locking screw, the end of the latter can enter the hole. Hence to release work from the vice, the looking screw is loosened by a quarter turn or so, the hinged plate is raised, and the movable jaw can be instantly opened to its fullest extent. When the new article has been inserted, the jaw is pulled forward into contact with it, the hinged plate lowered, and the work is gripped by a quarter turn of the screw. The vice has no loose fittings which may be lost, it is exceptionally handy to operate, and the design ensures the parallelism of the jaws being retained indefinitely.

THE TREATY OF PEACE; ENEMY DEBTS.—A set of instructions has been compiled for completing proof of claims against German debtors. These have been drawn up by the clearing office for the assistance of British creditors, and copies may be had from the Controller, Clearing Office (Enemy Debts), Cornwall House, Stamford-street, S.E. 1. These notes specify what debts are claimable. Instruction is given with regard to compensation, interests, proof of claims, partnerships, and so on. A 2½ per cent. commission will be chargeable on all claims paid. In the case of any debt payable under the Peace Treaty through the Clearing Office, it is unlawful for any person to pay or accept payment of it except through the Clearing Office.

TRINIDAD AND TOBAGO.—The report for 1918 on these two West Indian islands, issued by the Acting Colonial Secretary, states that owing to the shortage of tonnage and the closing of the Continental markets, the output of asphalt had been greatly reduced during the war, the exports in 1918 amounting to 56,799 tons, as against 206,416 tons in 1913. At the close of the year there were 12 companies engaged in the production of petroleum in the Colony. The number of wells drilled during the year was 41, bringing the total number drilled at December 31, 1918, to 410, of which 236 are on Crown lands. The quantity of oil extracted during the year was 72,872,398 imperial gallons, an increase of 16,791,484 gallons, as compared with 1917. The quantity exported amounted to 43,597,920 gallons, valued at 542,578*l.* as against 37,138,608 gallons valued at 402,063*l.* exported in 1917.

THE SCHNEIDER 155-MM. HOWITZER.

In the course of the late war, the 155-mm. (6·102-in.) howitzer and the gun of the same calibre, designed and built by Messrs. Schneider, rendered such invaluable service to the cause of the Allies that we asked the builders for permission to publish an illustrated description of both, permission which they readily granted. During the war, this *matériel* was manufactured in large numbers at their Creusot and Havre works, their other establishments in Paris and throughout France contributing in the matter of details and supplying all the essential accessory gear. We illustrate the howitzer in Figs. 1 to 5, and shall deal with the gun in a future issue.

The Schneider 155-mm. howitzer, formed an important component part of the Allies' heavy field artillery. It allows of curved fire and high-angle fire up to a positive angle of 43°; the limit of traversing is round an angle of 6 deg. With the use of charges varying in weight, it makes for wide angles of descent at all ranges. The maximum range is 12,000 m. (7·45 miles), the projectile weighing 43·750 kg. (96·425 lb.), containing an explosive charge of 4·5 kg. (9·918 lb.), the muzzle velocity being 450 m. (1,476 ft.). The charges are contained in divisible cartridge bags. The howitzer has a total length of 2·332 m. (7 ft. 7½ in.), and has 48 grooves, at a constant angle of right-handed twist of 7 deg. The height of the line of fire is 1·433 m. (4 ft. 8½ in.) and the height of the line of sight 1·640 m. (5 ft. 4⅝ in.). The length of the howitzer in firing position is 5·852 m. (19 ft. 2⅛ in.). No firing platform is required, nor is it necessary to scotch the wheels. When firing in very loose ground, rattan mats can be used to prevent the wheels from sinking down, and means can also be resorted to in order to increase the horizontal bearing of the trail spade. Four rounds can easily be fired per minute; the rate of fire can reach six rounds when the gun crew is trained and the charges are kept handy for such an accelerated rate.

The piece in the firing position consists of the howitzer, the carriage with the frame, the sledge fitted to the latter and connected to the howitzer. The howitzer is of steel and is built up of a tube, with jacket and equalising weight; it is provided with connections to the sledge and with rings to facilitate lifting.

The breech-closing device is of the screw type, with plastic obturator; it is operated by hand by one continuous action on the lever. In order to facilitate loading under all angles, the breech block hooks back automatically when completely opened out. The striker acts upon the percussion tube only when the breech is completely home. The sledge is of forged steel, and contains the hydraulic recoil buffer and hydro-pneumatic recuperator. It is joined to the gun by grooves and a collar, and recoils with the gun on the slide-paths of the frame. For wheeling, it can be made fast to the frame by two bolts. The recoil buffer has variable orifices and constant resistance, and contains a governor which acts for running up the gun. The compressed air in the system is never in contact with the packing boxes, and therefore these need only be watertight the liquid used is a mixture of water and glycerine. The frame is pressed out of a steel plate; it rests on the carriage by its trunnions and is made with slide-paths which guide the sledge over the whole recoil length. The aiming and sighting gears are mounted on the left-hand trunnion. The frame is extended to the rear so as to insure a perfect balancing of the oscillating mass on elevation; it is fitted with toothed sectors for elevation, and is provided with bolts for holding the sledge fast for wheeling. The firing gear also forms part of the frame and contains a safety device which prevents all firing action so long as the buffer and recuperator piston rods are not connected up. Since, as above stated, firing cannot take place until the breech is right home, most ample means of safety are provided.

The carriage is built of two flanged sides, of steel, strengthened by upper and bottom plates strongly cross-braced. It is fitted with the elevating and traversing gear, the axle and wheels, the road brake, the locking bolt on the axle for wheeling, the shield, trail spade, handspike and various accessories. The elevating mechanism consists of a set of toothed gearing having two pinions which act on the toothed sectors of the frame. The traversing mechanism consists of a series of toothed wheels and an endless screw engaged in a nut on the axle. The projectile is driven home in the shot chamber by a rammer and the powder charge inserted by hand. The limber forms a trail support and carries no ammunition.

The following are further figures concerning the howitzer:—

Carriage.

	M.		Ft.	In.
Wheel track	*1·520*	=	5	0
Diameter of wheels ...	*1·330*	=	4	4⅜
Width of wheel tyres ...	*0·150*	=	0	5⅞

THE SCHNEIDER 155-MM. HOWITZER.

FIG. 1. 155-MM. HOWITZER, SIDE VIEW.

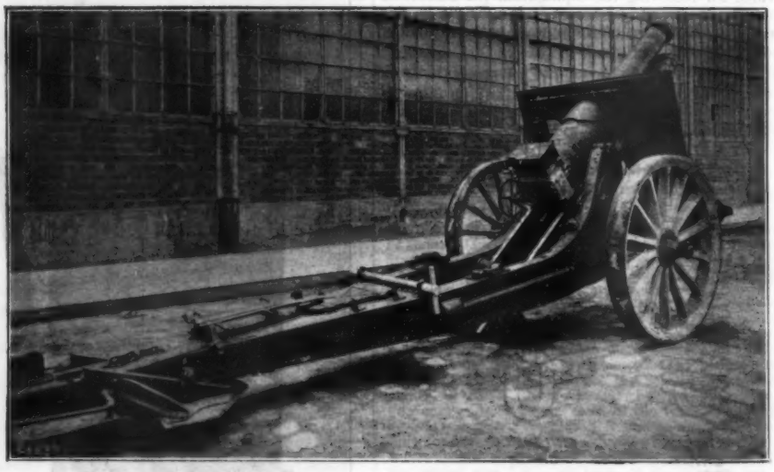


FIG. 2. 155-MM. HOWITZER IN FIRING POSITION.

Gun Team.

	M.		Ft.	In.
Length of limber without poles	*1·500*	=	4	11
Wheel track	*1·524*	=	5	0
Diameter of wheels ...	*1·220*	=	4	0
Width of wheel tyres ...	*0·070*	=	0	2¾
Total length with pole ...	*10·050*	=	32	11

Weights.

	Kg.		Lb.
Howitzer	*1,245*	=	2,744
Sledge	*377*	=	831
Frame	*328*	=	723
Carriage	*1,350*	=	2,975
Complete in firing position	*3,300*	=	7,273
Breech block	*85*	=	187
Shield	*96*	=	212
Carriage wheel (pair) ...	*268*	=	591
Limber wheel (pair) ...	*175*	=	386
Limber	*415*	=	915
Gun behind team	*3,716*	=	8,188

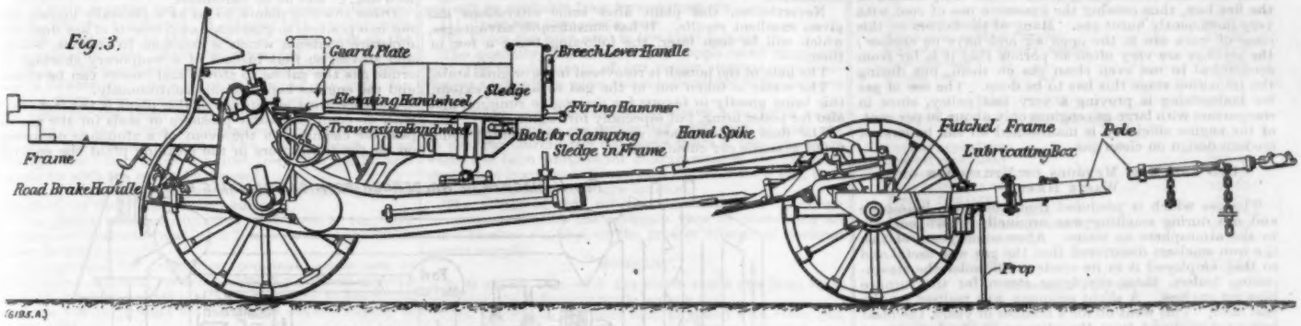
The hydraulic recoil buffer and hydro-pneumatic recuperator shown in the diagram, Fig. 5, contains, as above stated, a governor for running up the gun. The buffer cylinder *a* is the lower, left-hand cylinder of the sledge. The piston *b* does not recoil; its rod *c* is held fast to the front cross-bracing of the frame by a nut screwed and pinned to the front threading of the said rod, and by a shutter plate which forms part of the frame and is lodged in a groove of the nut. The piston rod *c* is hollow and contains the counter-rod, the internal hollow space being closed in front by a plug which is screwed down tight and pinned. The piston head *d* has a brass friction lining held in place by screws, and is made with annular passages as shown. The rear plug *e* is screwed tight upon a copper washer; it holds the counter-rod and carries the plug which closes the filling-up port. The front packing is also shown in Fig. 5, and is so devised that its initial tightness increases gradually as the liquid pressure rises. The counter-rod *g*, which participates in the recoil, is screwed and pinned in the rear nut of the buffer system; it varies in section, the diameter being smaller towards the rear, thus ensuring a constant resistance at every instant of the period of recoil; it is also provided from the front part, and over a given length, with a brass lining made with centring studs. Its piston-shaped head is an easy sliding fit in the hollow piston rod; it is provided with a valve in front, the travel of which is very small and is limited by the shoulder of a steel ring screwed and pinned on the front end of the counter-rod. An annular port is cut in the front of the piston-shaped head for the flow of the liquid.

When a round is fired, the gun recoils and draws back the sledge, the buffer cylinder and the counter-rod with it, whilst the piston which is connected to the frame does not move. By this means, the liquid is compelled to flow from front to rear by the opening *f* in piston *d*, which varies in free section as the counter-rod of varying diameter runs through it. The friction of the liquid, as this is compelled to flow at a high velocity through a narrow annular space at *d*, gives rise to a resistance to recoil, the annular space as it varies being calculated to yield a practically constant resistance for a recoil, the length of which is about 1·28 m. (50·393 in.). The annular space would be completely closed by the counter-rod were the recoil travel to reach 1·305 m. (51·377 in.). It never exceeds 1·30 m. (51·181 in.). The liquid also enters the hollow space round the counter-rod, the piston-shaped head being away from its seat.

On the gun running up, the sledge travels forward with the buffer cylinder and the counter-rod, the liquid travelling back inversely, but the stress which makes for running up being different in character from the one which made for recoil, the variation in the flow spaces due to the differences in diameter of the counter-rod would not suffice, alone, to insure a regular running-

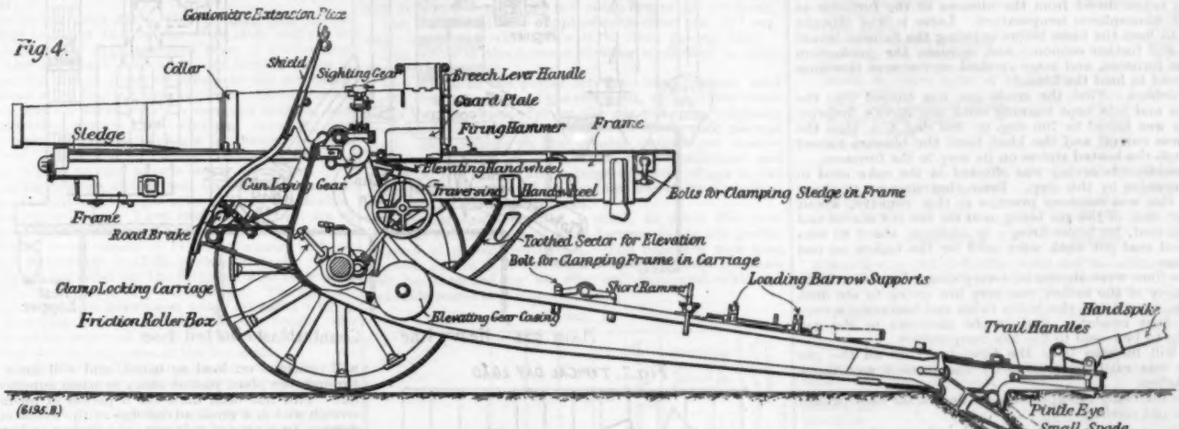
THE SCHNEIDER 155-MM. HOWITZER.

Fig. 3.



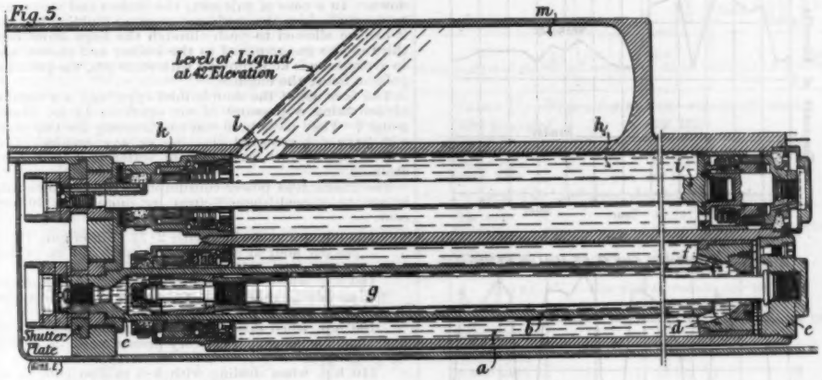
(6195.A.)

Fig. 4.



(6195.B.)

Fig. 5.



(6195.E.)

up. Here the piston-shaped head of the counter-rod comes into play. The pressure of the liquid which has filled the space in the piston rod drives the head in its seat and closes its ports. The liquid can thus only flow to the rear by passing through the annular space between the piston-shaped head and the piston rod; a governing action is set up and running-up takes place smoothly and regularly. Near the end of the action the counter-rod tends to act as a hydraulic buffer, and prevents a shock which might displace the trail spade.

In running-up a recuperator comes into play, its acting being to store up a part of the *vis viva* of recoil and to restore it at the right moment for placing the gun back in firing position. It consists of the cylinder *h*, being the lower right-hand cylinder of the sledge. The piston *i* does not recoil, and is held fast to the front cross-brace of the frame; it is drilled in front at the top for lubricating the packing. The piston *i* is provided with a packing similar to that at the opposite end of the brake cylinder, as also is the packing *k*. The port *l* insures communication with the two air reservoirs, these being the cylinders *m* above the sledge, filled in part with compressed air and in part with the liquid, the level of the latter varying with the elevation of the howitzer.

When a round is fired, the gun recoils and draws back the sledge and the recuperator. The piston, being connected to the frame, does not move. The packing preventing the flow of the liquid, this is driven in the reservoirs and compresses still further the air in the latter. When the recoil stress has ceased, the air expands and drives back the liquid inversely. The initial pressure in the recuperator is largely sufficient to maintain the gun in the firing position at every angle, and the final pressure is also largely sufficient to insure running-up in every instance. The recuperator has been designed to yield an excess of power, this being combined with a braking action of the governor, which becomes greater as the running up force increases. This overcomes any difficulty in running-up which might be due to various causes, such, for example, as the presence of grit on the slide-paths.

For the road, the howitzer and sledge are brought back to the rear of the trail and maintained in that position, so as better to distribute the load on the carriage and limber wheels. (See Fig. 3.) For short distances, the howitzer can easily be wheeled without any such preparation.

(To be continued.)

RAILWAY CONSTRUCTION IN PERU.—It is reported that the construction of new railways has now been approved by the Peruvian Government, and it is likely that some 996 km. (620 miles) of track will be laid down in the near future. H.M. Commercial Secretary at Lima has telegraphed to the Department of Overseas Trade requesting that United Kingdom manufacturers of locomotives, rolling-stock and rails, who may be interested in the supply of the required material, should immediately furnish him with copies of their catalogues, for transmission to the Peruvian Railway Bureau, Ministry of Public Works, Lima.

THE PRODUCTION OF POWER FROM BLAST FURNACE GAS.*

By S. H. FOWLES, Associate Member.

SIR CHARLES A. PARSONS mentioned in his presidential address to the British Association at Bournemouth in 1919, that the latest estimate of our total water power in the British Isles is only 1,500,000 h.p., and that England possesses only 1 per cent. of the water power and only 2½ per cent. of the total coal in the world.

In view of this fact and that we as a nation have to make a considerable saving in our fuel consumption, we must first of all look to our efficiency. In many cases this is very low and wasteful. It is for us to look for better methods of using our wasted heat units, and thus make the best use of what we have, before attempting to harness any new powers.

One instance of great wastage is in the form of blast furnace gas, which escapes from the furnaces during the making of pig-iron, and it is to give some rough outline of the better way in which this gas can be, and is being used, that this paper is written. The author hopes that it will prove of some little value to all engineers.

The amount of energy which is at present being wasted or used at about 10 per cent. efficiency from the blast furnaces of this country is in the neighbourhood of 1,000,000 h.p. This is a matter that should be seriously taken up in connection with the greater power scheme, and should serve a very good purpose in the cheapening of electrical energy.

Balance Sheet No. 1 in the Appendix shows the savings that can be effected where the gas is cleaned and used efficiently; thus, for the same quantity of gas an additional 10,000 h.p. can be produced, and about 5,000 h.p. to 6,000 h.p. saved on coal, making a net saving of about 16,000 h.p. from three blast furnaces.

The gas is a by-product and has been treated in the past as of very little value, being therefore either wasted or used very inefficiently. The furnaces are self-contained, with a large number of boilers for steam-raising to supply the blast engines for the furnace blowing. This blast in turn passes from the engine-driven blowers through the hot stoves to the furnaces. The hot stoves and boilers usually consumed the whole of the gas made, in addition to a very large amount of coal for the boilers.

The gas was used in its crude state, with the exception of the small amount of dust taken out by the dust catchers, which amounted to about 20 per cent. of the initial dust in the gas, the dust quantities at this point being in the neighbourhood of 8 grammes per cubic metre. This considerably choked up the boiler tubes and flues, and caused great loss in laying off the boilers for cleaning, which was a very frequent occurrence

* Paper read before the Institution of Electrical Engineers, on Thursday, March 11, 1920.

when it is seen that the boilers consumed about 1,000,000 cub. ft. of gas per hour.

In addition to the dust, the moisture had to be dealt with, and this considerably lowered the temperature of the fire box, thus causing the excessive use of coal with very inefficiently burnt gas. Many of the boilers on this class of work are in the open air and have no shelter; the settings are very often so porous that it is far from economical to use even clean gas on them, but during the transition stage this has to be done. The use of gas for boiler-firing is proving a very bad policy, since in comparison with large gas engines only about 30 per cent. of the engine efficiency is maintained on the boilers of modern design on clean gas.

OLD AND NEW METHODS OF UTILISATION OF WASTE HEAT.

The gas which is produced from the coke, limestone and ore during smelting was originally blown entirely to the atmosphere as waste. After some years of this the iron smelters discovered that the gas was useful and so they employed it in its crude state under the steam-raising boilers, these supplying steam for the furnace blowing engines. A slight economy was realised on the coal used. This went on for a number of years, the blast being taken direct from the blowers to the furnaces at about atmospheric temperature. Later it was thought that to heat the blast before entering the furnace would be a still further economy and increase the production of the furnaces, and large vertical stoves were therefore designed to heat the blast.

Operation.—First the crude gas was turned into the stoves and was kept burning until the stove's firebrick lining was raised to 700 deg. to 800 deg. C.; then the gas was cut off and the blast from the blowers turned through the heated stoves on its way to the furnaces.

Considerable saving was effected in the coke used in the furnaces by this step. From that time up to about 1913 this was common practice in this country, about 40 per cent. of the gas being used for the hot stoves and 60 per cent. for boiler-firing; in addition, about 80 tons of good coal per week were used for the boilers on one furnace.

The flues were always in a very clogged state and the efficiency of the boilers was very low owing to the dust in the gas coating the boiler tubes and becoming a very good heat insulator, and to the moisture in the gas having to be raised to fire-box temperature.

It will be seen from the foregoing that all the gas made was easily consumed by the furnace auxiliaries themselves.

The following are approximate figures for one furnace on the old method :—

Gas made per hour	...	1,000,000 cub. ft.
Gas used on hot stoves	...	0·4 million cub. ft.
Gas used on boilers	...	0·6 million ,,
Total gas used per furnace		1·0 million ,,

Coal used per furnace per hour = 0·5 ton.

The furnace blowing averaged about 600 h.p.

So that 600 h.p.-hours took 0·5 ton of coal + 600,000 cub. ft. of gas at 100 therms per cubic foot.

Now therms in coal at, say, 13,000 per lb. = 14,560,000
Now therms in gas at, say, 100 per cub. ft. = 60,000,000

Total therms 74,560,000

This number of therms used as gas in our present-day gas engines would develop about 6,500 h.p., which shows the old method of using crude gas and coal to have an efficiency of about 10 per cent. when compared on a horse-power basis with our present-day gas-driven plant.

The following are approximate figures for one furnace on the new method :—

Gas made per hour	...	1,000,000 cub. ft.
Gas used on hot stoves	...	0·4 million ,,
Gas used on boilers	...	Nil
Gas used per furnace on blowers		0·15 million ,,
Total gas used per furnace		0·55 million ,,

Coal taken per furnace per hour for hoists = 0·2 ton.

Furnace blowing = 800 h.p. owing to increased production due to higher stove temperature on clean dry gas.

So that 800 h.p.-hours take 0·2 ton of coal + 150,000 cub. ft. of gas at 100 therms per cub. ft.

Now therms in coal at 13,000 therms per lb. = 5,824,000
Now therms in gas at 100 therms per cub. ft = 15,000,000

Total therms 20,824,000

Therefore each furnace produces 1,000,000 cub. ft. of gas per hour and only 0·55 of this is required for the furnace, leaving 0·45 millions or 450,000 cub. ft. of gas available per furnace for other purposes, and this at 150 cub. ft. per kilowatt-hour is equal to about 3,000 units of electricity per furnace per hour.

Now with 80 furnaces the aggregate would equal 150,000 units saved per hour and 1,030,510,000 per annum; this with the boiler saving represents an economy of about 400,000 tons of coal per annum. This shows that the electrical energy which can be saved annually by generating from blast-furnace gas is almost equal to the total number of units sold during 1911–1912 by all the 303 electricity works of the United Kingdom, as mentioned in Balance Sheet No. 1.

Balance Sheet No. 1 shows the difference in coal and gas consumed, and the work done under crude and clean gas conditions respectively, and it will be realised that the saving is enormous. A great deal depends on the selection of a cleaning plant for this purpose, and while it is not intended to compare the merits or demerits of other plants, yet a great deal can be said for the Halberg-Beth type. So far as this plant is concerned it is a dry gas-cleaning plant, but water was used in direct contact with the gas in the pre-coolers, and this has now been eliminated.

Nevertheless, this plant after some alterations has given excellent results. It has considerable advantages, which will be seen later, the following being a few of them :—

The bulk of the potash is recovered in its original state.

The water is taken out of the gas to a large extent, this being greatly in favour for gas-engine running, and also for boiler firing, but especially for engine use.

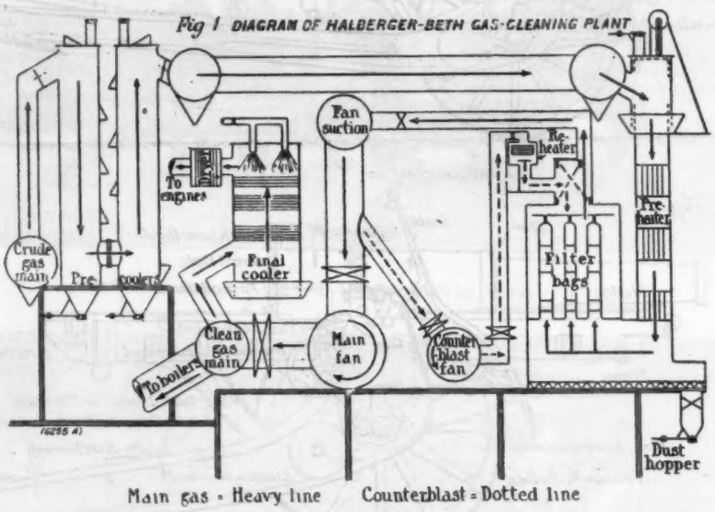
The dust contents are very low, the average being 0·002 gramme per cubic metre.

3·3 million cub. ft. of gas per hour, and is provided with fans of a nominal total capacity of 4,000,000 cub. ft. of gas per hour, the gas quantities being taken at 0 deg. C. and 30 in. barometer.

Other cleaning plants, so far as is generally known, are not in a position to guarantee such results of low dust and moisture contents which is common to engines, boilers and stoves, so that in case of a temporary shortage of crude gas the valves to stoves and boilers can be closed and the engines kept running continuously.

Another great advantage of this plant is the fact that, with no complete water passages or seals for the gas to pass for cleaning, in the event of a stoppage occurring on all the fan motors in the cleaning plant the engines

Fig 1 DIAGRAM OF HALBERGER-BETH GAS-CLEANING PLANT



Main gas - Heavy line Counterblast - Dotted line

Fig.2. TYPICAL DAY LOAD

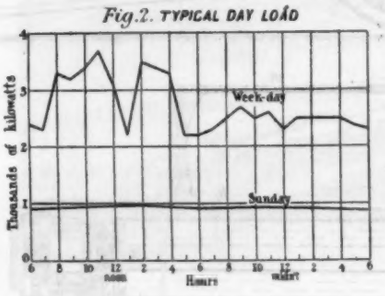
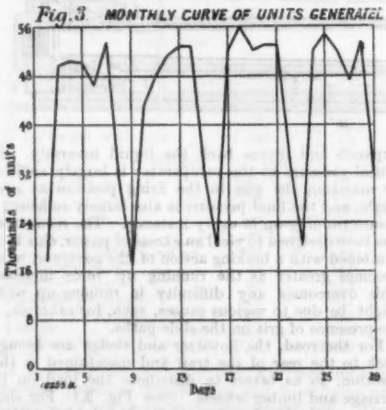


Fig.3 MONTHLY CURVE OF UNITS GENERATED



The plant can be worked for long periods up to 30 per cent. overload if required.

The moisture can be removed or allowed to remain at will.

The total water contents average about 15 grammes per cubic metre. This is very low, and of great advantage in gas-engine running. Many alterations have been made in the operation of the plant to obtain these conditions, the original German plant being designed for boiler-firing only where gas of a higher dust and moisture content was tolerated, but was eventually arranged to clean gas of sufficient cleanliness and dryness for engine consumption.

The above figures can hardly be surpassed to-day on any plant when the dust and moisture are taken into consideration jointly and the power consumption per volume of gas cleaned.

The plant consists of three filter units of 11 double compartments each, with a total nominal capacity of will continue on load as usual, and will draw the gas through the plant just as clean as when supplied by the fan. This has been done for a period of an hour at a stretch and is a great advantage in the event of a shut-down. In a case of this sort, the boilers and stoves are kept supplied by the crude gas pressure building up, and it can be allowed to push through the bags about one-third of the gas required to the boilers and stoves, and so everything is kept moving with some gas, the principal portion being the engines.

The fans are of the double-inlet type, and are capable of delivering a pressure of air equal to 12 in. (water gauge). They have been run continuously for two years and have not required cleaning or any repairs. This will show the low quantities of water and dust after cleaning.

The guaranteed power consumption is as follows, and is not to exceed these figures by more than 10 per cent. :—

150 h.p. when dealing with 2·75 million cub. ft. of gas per hour at a delivery pressure of 2 in. (water gauge).
180 h.p. when dealing with 2·75 million cub. ft. of gas per hour at a delivery pressure of 4 in. (water gauge).
180 h.p. when dealing with 3·0 million cub. ft. of gas per hour at a delivery pressure of 2 in. (water gauge).
210 h.p. when dealing with 3·0 million cub. ft. of gas per hour at a delivery pressure of 4 in. (water gauge).

The motors are direct-current, shunt-wound, interpole 500-volts 160-b.h.p. machines and run at 900 r.p.m., and are of variable speed up to 1,170 r.p.m.

The actual consumption is as follows :—

95 h.p. when dealing with 1·35 million cub. ft. of gas per hour at a delivery pressure of 4½ in. (water gauge).

These figures show a slight reduction on the guaranteed figures equal to about 3 per cent. in favour of the guarantee. This becomes a considerable item in the year, since with two fans running, and taking a total of 1,448,200 units per annum, the saving equals 44,000 units. This saving has been brought about absolutely by dry and clean gas working, in order to keep the fan dealing with a gas as high in density and as low in temperature and moisture as possible. The result is, that after two years' hard working the fans are more efficient than the maker's guarantee figures.

The total area of filtering medium is 16,632 sq. ft., and 5 per cent. of this is automatically shut off every 10 minutes for shaking and cleaning. The dust which is recovered from the cleaning of the gas is about 50 tons per week, and is equal in potassium chloride to about 30 per cent.

The general operation of the plant is as follows :—

The crude gas is first cooled in the pre-coolers and lowered in temperature from about 200 deg. to 80 deg. C., a large amount of dust and moisture being deposited. It is then heated up about 10 deg. or 15 deg. C. to allow of the gas passing through the plant with its moisture contents superheated, and not to be influenced by the surrounding atmosphere, which is liable to deposit moisture and so clog up the filter bags. The gas then passes the filter bags where it is cleaned and its dust

removed, afterwards passing to the main fans, and is finally delivered by them to the respective places for consumption.

Immediately above the main fans, and on the suction side, a main is taken out to supply the counterblast fan, which delivers a quantity of cleaned gas continuously through a reheater to the clean side of the bags in the compartments only that are open for cleaning and shaking. During this operation the shaking gear operates a double-way valve, thus cutting off the main fan suction from that particular compartment and opening the path for the clean counterblast gas, which is at a pressure of a few inches (water gauge) above the pressure at the pre-heater bottom. The counterblast flows through the bags, takes the dust from the inside, and passes on with the gas to be cleaned.

The arrangement is shown in Fig. 1, from which the simplicity of the plant will be realised.

The plants work continuously and have a very low upkeep and operation cost, as will be seen from the tables given in the Appendix.

The engines for generation comprise seven sets of 12-cylinder tandem vertical 1,500 h.p., direct-coupled to 1,000-kw. three-phase alternators running at 200 r.p.m. and are run in parallel with a public electric supply at 5,500 volts.

In order to get good firing, the sparking plug points are adjusted to about 15/1,000ths of an inch, and are of the motor-car large type supplied from a low-tension magneto and induction coil, and very little trouble is experienced by dirt or moisture owing to the gas being dry and clean when leaving the gas plant. The throttles for air and gas are arranged on a common spindle, and the air throttles require more cleaning than the gas throttles, which shows that the gas is cleaner than the atmosphere. The machines run very steadily and synchronising is quite as easy as on a steam-driven set.

The blowing engines of four sets are of the horizontal type with two double-acting gas cylinders and one double-acting blowing cylinder. They run at 85 r.p.m., are of 1,650 h.p. and can deliver 36,000 cub. ft. of free air per minute up to a pressure of 11 lb. per square inch, or a decreased volume up to 15 lb. per square inch. These engines supply the blast for the furnaces, and have been in operation for 1½ years very successfully. The ignition is on the low-tension drawn-out plug, operated with a solenoid in series, so that directly the arc breaks, the plunger is spring-returned ready for the revolving contact passing its brushes again on the lay shaft.

The gas is quite free from tar, and pistons drawn after six months' running were found to be as clean as when first installed.

A great deal of attention has been given to the operation and maintenance of the cleaning plant, as it was very early decided that we must have clean gas. This being as clean as town gas and of low calorific value but very constant, makes gas engines as reliable as steam engines.

During the early periods of operation it was decided to overhaul the engines twice per annum, but after several inspections it was found that we were able to run for 12 months before overhauling. The usual repair common to all engines are taken in hand at the week-ends.

Several tables are given in the Appendix to show the various constitutents of the gas, the constant value, the gas and oil used in various parts of the works, the number of units generated, and the pressures and temperatures maintained at various positions in the cleaning plant and engine rooms.

The exhaust gases have been tested and the following is the average of the general tests taken :—

Number of Engines Working.	Temperature.	N	CO_2	CO	O
4	Deg. C. 337	per cent. 78	per cent. 14·0	per cent. 0·26	per cent. 8·3

Table 1 shows the constituents of the gas, the therms per cubic foot, the dust and moisture contained in the clean gas, and the quantity and contents of the dust. Table 2 sets out the results in the engine room on the generating engines. Table 3 shows the quantities used at the blowing engines. Table 4 deals with the gas cleaning plant, while Table 5 deals with the gas temperatures and pressures in the gas plant and the engine room respectively.

Curves of the various loads are given in Figs. 2 and 3, and show the usual conditions in iron and steel works. A great deal depends on these conditions as to how the electrical world can make great use of the intervals should all the blast furnaces of this country become interconnected with the greater scheme of power supply.

In the daily load curve (Fig. 2), it will be seen that from 5 p.m. to 7.30 a.m. about 3,000 k.w. of plant is idle. The whole of the gas is wasted during this period, and could be very usefully employed to supply power to a network through converting plant, thus allowing several medium-sized towns to take their supply from such a source and reduce considerably their coal, stores, and probably their wages costs during this period.

A still greater loss is shown on the Sunday curve from Saturday noon to 7.30 a.m. on Monday, when 4,000 kw. of plant is idle and could deal with the week-end load of several medium-sized towns, thus allowing the boilers in use and the staff to be considerably reduced and effecting a great saving of fuel and wages. It would also allow of a good many repairs being done, and so decrease the stand-by plant in many cases.

This matter should be considered seriously, as already we are making use of our water supplies which are not so constant as this supply. We have now some 50 places in this country where blast furnaces are working and these are to be increased during the next few years. Many of these places cannot consume the whole of their gas produced, and with the adoption of cleaning plants such as have been mentioned, and the use of large gas engines, the time has arrived when still more and more gas will be available from two sources, viz.—

(1) From the coke ovens, and

(2) From the coke used in the blast furnace.

The quantity of gas wasted, although small compared with the requirements of our power stations, is nevertheless a large item when taken collectively in the balance sheet.

The coke-oven gas mentioned above is richer in value than blast-furnace gas and is not quite such an easy gas to use, but during the last three years a very ingenious valve has been adopted for mixing some of the exhaust-cooled gas from the engines with the coke-oven gas, thus avoiding the trouble of pre-ignition.

The whole of this subject should have a thorough investigation, with the ultimate view of connecting all blast-furnace supplies to the greater scheme of national power supply.

SUMMARY.

It is shown that with the waste crude gas from three furnaces the following work is done :—

The hot stoves are kept fully supplied with clean gas, and consume about 1,000,000 cubic feet of gas per hour.

The boilers are fully supplied with clean gas, and consume about 0·6 million cub. ft. of clean gas per hour.

The whole of the furnace blowing is effected by large gas-driven engines.

The whole of the power for the blast furnaces, steel works' rolling mills, and the shipyard, which totals about 5,000 kw., is obtained from the gas that was originally consumed for the furnace auxiliaries when crude gas was used. In addition to the greater output, we recover the large amount of potash previously mentioned and shown in the tables, and a large quantity of gas is still being wasted and could be used for electricity generation as shown in the balance sheet.

Sufficient has been said, I think, to prove the great use that can be made of blast-furnace gas in the greater scheme of power production. The base has now been formed, and it is to be hoped that the highest efficiency will be obtained by all who are connected with this valuable heat-raising source.

TABLE I.

	N	CO_2	CO_2	H	Therms per cub. ft.	Grammes per cubic metre in Clean Gas.		Chlorides as KCl, Recovered Dust.
						Dust.	Moisture.	
Constituents of gas	p.c. 60·8	p.c. 7·86	p.c. 28·1	p.c. 2·32	98·5	0·0023	15·0	p.c. 30·637

TABLE II.—*Generating section—results per week.*

Units generated	396,350.
Gas used	59,452,500 cub. ft.
Oil used	34 gallons.
Grease used	30 lb.
Waste used	95 lb.

TABLE III.—*Blowing section—results per week.*

Gas used	49,247,000 cub. ft.
Oil used	95 gallons, *i.e.*, 0·284 gallons. per engine hour.
Grease used	35 lb.
Waste used	56 lb.

TABLE IV.—*Gas plant—results per week.*

Gas cleaned	468,216,000 cub. ft., or 2,787,000 cub. ft. per hour.
Bags changed	8.
Oil used	8 gallons.
Grease used	10 lb.
Waste used	12 lb.

TABLE V.

Gas Temperatures.	Atmosphere, 16 deg. C.	Crude Gas, 250 deg. C.	After Coolers, 66 deg. C.	After Pre-heaters, 32 deg. C.	Stoves and Boilers, 73 deg. C.	Engines, 22 deg. C.	Counterblast, 107 deg. C.
Pressures, inches (water)	—	+4·2	−0·2	−3·9	+4·8	+5·7	+3·8

APPENDIX.

Balance Sheet and Old and New Methods.

	Old Method.	New Method.
Gas made per furnace per hour	1,000,000 cub. ft.	1,000,000 cub. ft.
Furnace rate of working	Normal	10 per cent. increase
Coke per ton of pig-iron made	23 cwt.	21 cwt.
Units of electricity generated per furnace per annum	Nil	6,870,000
Potash saved per annum	Nil	6,000*l.*
Flue cleaning costs per annum	1,000*l.*	Nil
Coal used per furnace per hour	0·5 ton	0·2 ton
Horse-power developed per furnace per hour	600	800
Therms used per furnace per hour	74,560,000	20,824,000
Gas used per furnace per hour	1,000,000 cub. ft.	550,000 cub. ft.

BALANCE SHEET No. 1.

Showing the saving by cleaning and using blast-furnace efficiently. The comparisons are taken over a working year.

Old Method.

	l.
Coal used on boilers	19,350
Extra coke used on furnaces	13,650
Cost of electrical energy bought	88,540
Flue cleaning	1,000
Potash lost	6,000
Total	128,540

New Method.

	l.
Capital expenditure	200,000
Annual repayment	30,000
Coal saved per annum	18,000
Coke saved per annum	13,650
Potash recovery	6,000
Saved on units generated	70,834
Saved on extra units generated	28,340
Saved on flue cleaning	1,000
Total	137,824

Summation Balance.

	Dr. *l.*	Cr. *l.*
Capital to repay	30,000	
Coal saved		19,350
Coke saved		13,650
Saved on electrical energy		88,540
Saved on flue cleaning		1,000
Saved on potash recovery		6,000
Saved on extra units of electricity generated		35,425
Total wages paid per annum	16,300	
Wages on old boilers	2,900	
Total oil costs	2,912	
Total stores	1,000	
	54,612	163,965
Units generated per annum		20,610,200
Saving, gross	163,965	
Less capital and wages	54,612	
Net saving	109,353	

Comparison of 303 electricity works and the estimated waste gases of Great Britain's 50 blast-furnace plants :—

303 Electricity Works.	1911–12.	50 Blast Furnaces.
Capital expenditure	63,788,732*l.*	10,000,000*l.*
Total revenue from all sources	8,675,900*l.*	8,195,750*l.*
Working expenses	4,086,704*l.*	2,730,600*l.*
Gross profit	4,589,196*l.*	—
Net profit	2,880,939*l.*	5,465,150*l.*
Number of units sold	1,127,499,742	1,030,510,000
Working costs per unit	0·87*d.*	0·3*d.*
Plant capacity in kilowatts	961,520	565,000
Capital per kilowatt of plant capacity	67*l.*	17·7*l.*

SAFETY DEVICES IN TIN-CAN PLANT.—The power press used in tin-can works used to be the most dangerous machinery next to the circular saw, and accidents in Canadian works were deplorably frequent. The adoption of various guards has improved matters of late. The lids of the cans are no longer fed into the machine by the operator, but are fed from a tray on to a travelling belt, or the feeding table is provided with a reciprocating motion going forward under the punch for the stroke and returning for the removal of the punching and its replacement by a new piece; the operations are watched through a transparent screen. The rotary cutters which slit the sheet tin into strips are now provided with an iron guard so sloping down under the knives that only a narrow opening for the introduction of the sheet is left. *Canadian Machinery*, in describing these devices, also mentions a device used in the manufacture of talking machine records, in which a flat disc, 10 in. diameter, of soft material, is pressed between two dies. As soon as the die begins to descend, a guard moves in front of the machine pushing the attendant's hands away.

NEW SOURCE OF ALCOHOL.—The Bulletin of the Imperial Institute discusses the possibility of utilising the mowra flowers of India for obtaining alcohol. These flowers possess thick, juicy petals, rich in sugar. They are used by the natives as a foodstuff and especially for the preparation by fermentation of an alcoholic liquor called *daru* or *mohwra* spirit. A single tree will yield as much as 200 lb. to 300 lb. of flowers in a year. The tree also produces a valuable oil seed, which is exported in fairly large quantities to Europe. During the war the flowers were used in India for the production of acetone, the yield being said to be ten times as much as that obtained by distilling wood, which is the usual source of this substance. The demand for acetone in India in peace times, however, is not great, and large quantities of the flowers would be available for the manufacture of alcohol, and would appear to be an exceptionally cheap source of this material as the yield is high compared with that from potatoes and other materials commonly used, about 90 gallons, of 95 per cent. alcohol being obtainable from 1 ton of dried flowers. It has been estimated that in the Hyderabad State alone there are already sufficient mowra trees for the production of 700,000 gallons of proof spirit per annum, in addition to that necessary for the local liquor requirements. It is suggested that the most profitable way of utilising the flowers would probably be as a source of mixed motor spirit of the "natalite" type for use in India. That motor spirit can be produced on a manufacturing scale in India from mowra flowers has already been demonstrated, and it is stated that running trials with the spirit proved satisfactory.

70-CWT. ELECTRIC BATTERY TIPPING WAGON.

THERE are probably few firms with a longer record of notice in our columns than Messrs. Ransomes, Sims and Jefferies, Limited, of Orwell Works, Ipswich. It is, of course, mainly in connection with agricultural machinery that the firm's name is known, but some time ago they decided to extend the scope of their manufacture by taking up the building of electric battery vehicles. They were, we think, the first firm actually to begin this new line of work in this country, thus directly connecting a new industry with the name of one of our oldest engineering firms. In illustration of the class of work which Messrs. Ransomes, Sims and Jefferies are now turning out for the electric battery vehicle market, we illustrate on this page and pages 447 and 448 one of their latest models of battery-driven tipping wagons. The general appearance of the machine is well shown in Fig. 1. It has a capacity of 70 cwt., and is fitted with a tipping body which can be tipped either by hand or electrically in 40 seconds. The vehicle is purposely designed with low loading lines.

The general constructional features of the wagon are clearly shown in Figs. 3 to 5. The chassis is practically designed on motor-car lines. The frame is of pressed steel, and the springing is by half-elliptic laminated springs. The eyes of the spring are provided with bronze bushes to form bearings for the shackle pins. The axles, both front and rear, are of H-section steel forgings, while the wheels are of wrought steel pressed plates riveted on to cast-iron hubs. They are carried on Timken roller bearings. The steering gear is of the worm-and-segment type, but is of special design, embodying the Ackerman principle. The wheels pivot on a point immediately below the stub-axle pin. This is beneficial to the gear as a whole, and to the tyres in particular. The controller is placed under the driver's seat in a position where it can easily be cleaned. It contains a main drum and a starting drum. The former is connected to a controller handle moving in a gate, and gives four forward speeds and one reverse. The starting drum is attached to a foot pedal placed convenient to the driver's left foot, and is arranged that, when depressed, in the same way as a motor-car clutch pedal, the main current is broken. The driving of an "Orwell" vehicle is thus much the same thing as the driving of an ordinary petrol vehicle, and, after very brief practice, any driver can take it over.

In the operation of the gear all heavy current is broken on the starting drum, which is equipped with magnetic blow-out arrangements, the main drum making the various necessary connections without any current being broken on it at all. This latter drum should consequently last for an indefinite period. The driving motors are two in number. They are of the direct-current totally-enclosed compound type, and are secured to the longitudinal and transverse members of the chassis frame. The motor casings are of aluminium, and a cover is fitted which allows of easy access to the commutator and carbon brushes. The drive from each motor is transmitted through reduction gear to a countershaft carried alongside each motor, as shown in Fig. 6. The final drive from the countershafts to the rear road wheels is by silent chain. The motor armature spindle and the countershaft are both carried on ball or roller bearings. The batteries are of the Ironclad-Exide type, and contain 40 cells, having a total capacity of 258 ampere-hours. The battery is arranged in two boxes, one on each side of the chassis, suspended between the front and rear wheels, and so arranged that the boxes can be easily withdrawn for examination of the cells. A battery box in its withdrawn position is shown in Fig. 2. The method of withdrawing the box is of interest. Handles at its sides when lifted up place the box on to a set of rollers, so that it can easily be moved. When back in position the boxes are provided with a cover and are practically watertight and dustproof.

A diagram showing the electrical connections of the gear is given in Fig. 7. From this the various connections made in the different positions of the controller may be traced through. When the controller is in the regenerative position a very efficient electric brake is brought into operation. In addition to this braking, however, the vehicle is fitted with two mechanical brakes to each rear wheel. They are of the internal-expanding type. One is applied by the foot pedal and the other by a side lever. Both are adjustable, and are fitted with compensating gear. The method of tipping will be seen in Figs. 3 and 4. Rollers pivoted to rods, which are connected to the frame carrying the body, are pushed along channel iron guides either by a hand-operated worm gear or by a small electric motor. This first causes the body to travel backwards; but when the rollers on which it runs reach stops at the ends of the channel guides, the effect of the push-rod is to cause the front end of the body to lift and so tip the load.

ELECTRIC BATTERY TIPPING WAGON.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED.

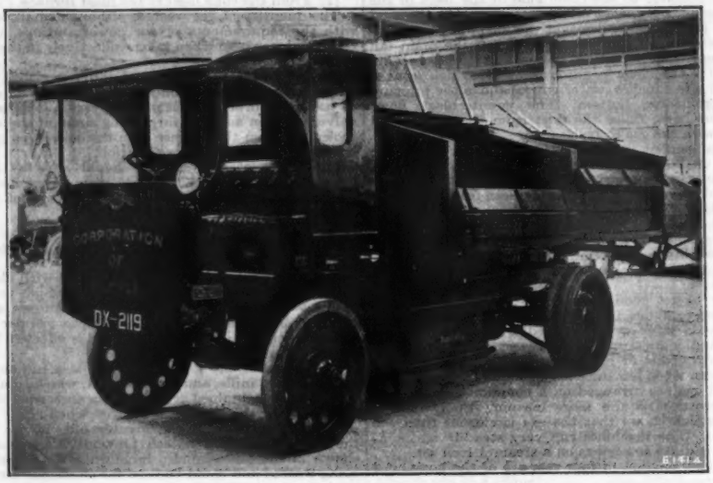


FIG. 1.

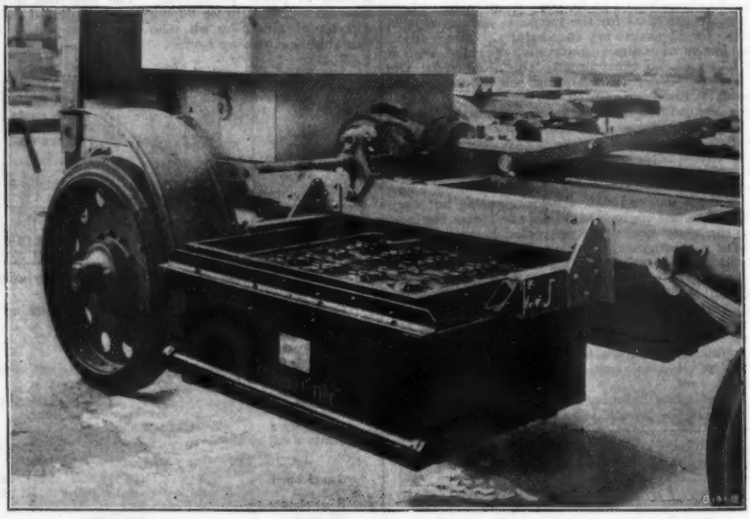


FIG. 2.

CLAIMS FOR WAR DAMAGE.—The Committee on War Damage state that forms for claims can be obtained on application to Mr. W. Neill, Controller, Reparation Claim Department, Board of Trade, Cornwall House, Stamford-street, London, S.E. 1. The forms are: (1) Damage due to loss of life of British civilians; (2) damage to British civilians due to personal injury; (3) damage to British civilians by loss of or injury to property; (4) damage caused to British civilians by being forced to labour without just remuneration. Claims which have been sent in to the Foreign Claims Office have been transferred to the new department, and no further action in these cases is asked for at present. It might, however, be advisable for claimants to obtain the forms and consider whether their original claims call for amendment. Particulars should be furnished of all injuries which have been compensated in whole or in part from private or public charitable funds, as in the end all such funds should be reimbursed.

IRON AND STEEL INSTITUTE.—The annual meeting of the Institute will be held at the Institution of Civil Engineers, Great George-street, Westminster, on Thursday and Friday, May 6 and 7, commencing each day at 10 a.m., and will be adjourned from Friday, May 7, to Friday, May 14, when a final Session will be held at the Mappin Hall, Sheffield, commencing at 3 p.m. The following is a list of the papers which it is expected will be submitted at the London meeting: Presidential Address; (1) Mr. C. A. Ablett, "Direct Current Compared with Three-phase Current for Driving Steel Works Plant"; (2) Mr. T. Baker and Mr. T. F. Russell, "Note on the Ball Test"; (3) Mr. F. Clements, "British Blast-Furnace Practice"; (4) Mr. J. A. Heskett, "The Utilisation of Titaniferous Iron Ore in New Zealand"; (5) Mr. W. E. Hughes, "Some Defects in Electro-Deposited Iron"; (6) Mr. E. H. Lewis, "Iron Portland Cement"; (7) Mr. G. F. Preston, "Practical Notes on the Design and Treatment of Steel Castings"; (8) Mr. C. H. Ridsdale, "The Valuation of Ores and Iron-making Material"; (9) Mr. J. H. Whiteley, "The Distribution of Phosphorus in Steel between Points Ac1 and Ac3"; (10) Mr. J. F. Wilson, "Notes on Slag Conditions in Open-Hearth Basic Steel-making Practice"; (11) Mr. H. E. Wright, "Chemical and Thermal Conditions in Blast-Furnace Practice"; (12) Mr. B. Yaneske and Mr. G. A. Wood, "The Reduction of Silicon from the Slag in the Acid Open-Hearth Process." The following is a list of the papers which it is expected will be submitted at the Sheffield meeting: (13) Mr. J. H. Andrew, Mr. J. E. Rippon, Mr. C. P. Miller and Mr. A. Wragg, "Effect of Initial Temperature upon the Physical Properties of Steel"; (14) Mr. C. A. Edwards, Mr. H. Sutton and Mr. G. Oishi, "The Properties of Iron-Chromium-Carbon Steels," Part I, Thermal Analysis; Mr. C. A. Edwards and Mr. A. L. Norbury, "The Properties of Iron-Chromium-Carbon Steels," Part II, "Effect of Heat Treatment on Electrical Resistivity"; (15) Mr. K. Honda and Mr. T. Murakami, "On the Structural Constitution, Hardening and Tempering of High-Speed Steel containing Chromium and Tungsten"; (16) Mr. J. H. G. Monypenny, "The Structure of some Chromium Steels"; (17) Mr. A. L. Norbury, "The Effect of Various Elements on the Electrical Resistivity of Iron"; (18) Mr. F. Rogers, "Brittleness of Nickel-Chrome and other Steels," Part II. The autumn meeting of the Iron and Steel Institute will be held in Cardiff, by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date for the assembling of members at Cardiff will be September 21, and the formal proceedings will open on the morning of September 22.

70-CWT. ELECTRIC BATTERY TIPPING WAGON.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED, ENGINEERS, IPSWICH.

(*For Description, see opposite Page.*)

Fig.3.

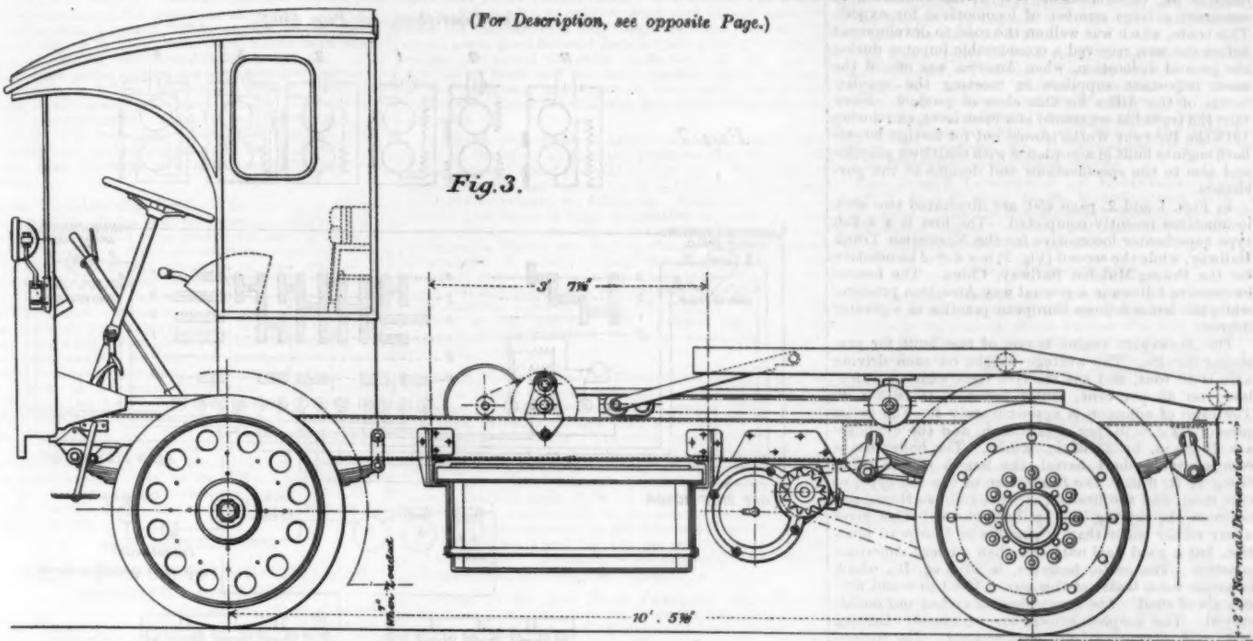


Fig.4.

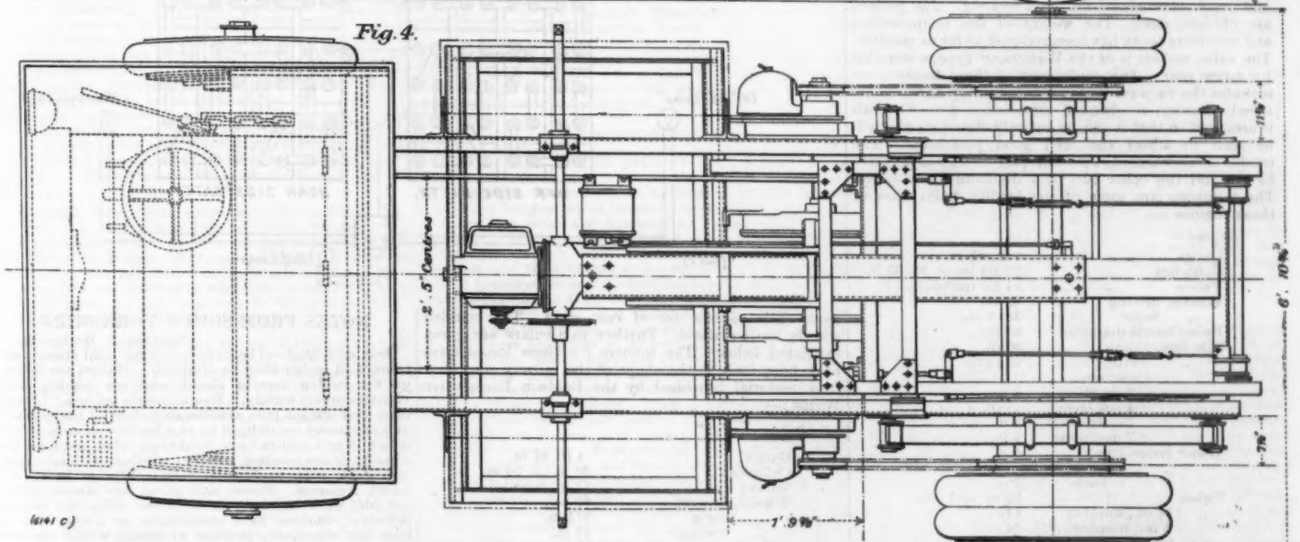


Fig.5

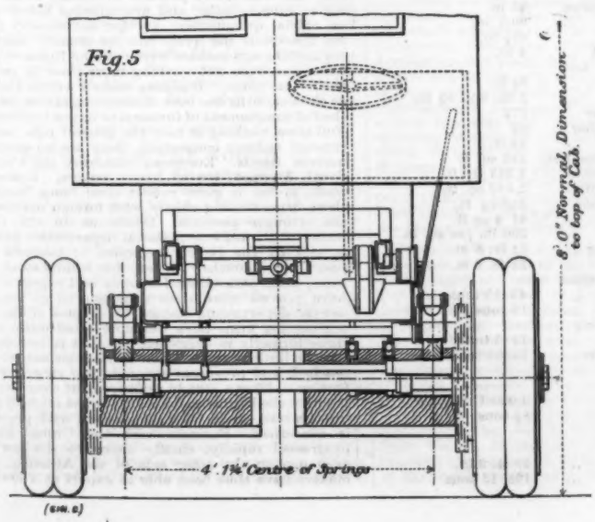
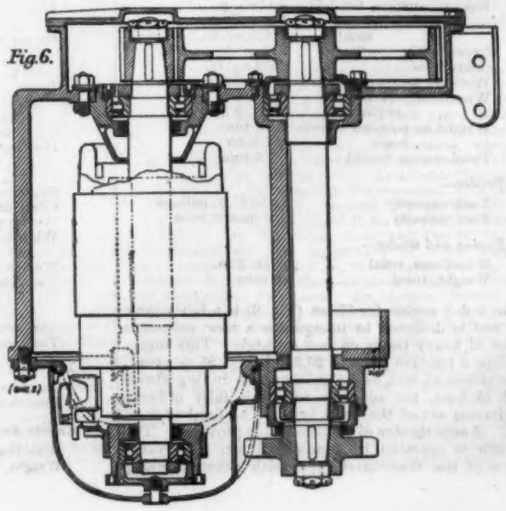


Fig.6.



LOCOMOTIVES FOR NORWAY AND CHINA.

DURING the past year the Baldwin Locomotive Works, of Philadelphia, Pa., U.S.A., whose London office is 34, Victoria-street, S.W. 1, has continued to construct a large number of locomotives for export. This trade, which was well on the road to development before the war, received a considerable impetus during the general dislocation, when America was one of the most important suppliers in meeting the requirements of the Allies for this class of product. Since then the trade has continued at a brisk level, and during 1919 the Baldwin Works turned out for foreign buyers both engines built in accordance with their own practice and also to the specifications and designs of the purchasers.

In Figs. 1 and 2, page 450, are illustrated two such locomotives recently completed. The first is a 4–6–0 type superheater locomotive for the Norwegian Trunk Railway, while the second (Fig. 2) is a 4–6–2 locomotive for the Peking-Mukden Railway, China. The former locomotive follows in a general way American practice, while the latter follows European practice to a greater degree.

The Norwegian engine is one of two built for passenger service. The average weight on each driving axle is 16 tons, and the tractive force exerted, calculated on 85 per cent. boiler pressure, is 26,300 lb. The ratio of adhesion is approximately 4. The boiler pressure is 170 lb. per square inch, and the cylinders are 22·05 in. by 23·62 in. stroke. The boiler has a comparatively short barrel, the length of the tubes being 12 ft. 6 in. The frames are of the bar type, of cast steel, and the fire-box is placed above them, and between the driving and trailing wheels. This gives a box rather wider than is possible in European practice, but a good deal narrower than modern American practice. The grate, however, is 26·4 sq. ft., which is ample for a boiler of this size. The tubes and fire-box are of steel. The crown sheet is arched and radial-stayed. The coupled wheels are equalised. Driving and crank-pins have been heat treated. The pistons are of cast steel. The weight of the reciprocating and revolving parts has been reduced as far as possible. The valve motion is of the Walschaert type, controlled by screw gear. The equipment of these locomotives includes the vacuum brake, with auxiliary hand brake, speed recorder, mechanical lubricators, &c. The cab is arranged so that it can be entirely closed in, and will be seen to afford the men good protection. The tender is six-wheeled, with one pair of wheels in horn-blocks and the other two in a diamond-frame bogie. The following are some of the leading particulars of these engines :—

Engine—	
Gauge	4 ft. 8½ in.
Cylinders	22·05 in. × 23·62 in.
Valves	9½ in. (piston)
Wheels, driving ...	63 in.
,, bogie ...	38·9 in.
Boiler barrel diameter	62 in.
Fire-box, length ...	90 in.
,, width ...	42½ in.
,, thickness—	
Side sheet	⅜ in.
Back sheet	7/16 in.
Crown sheet	⅜ in.
Tube sheet	½ in.
Water space, front ...	4 in.
,, sides and back	3 in.
Tubes	1¾ in. and 5 in.
,, 1¾ in., number	146
,, 5 in., number...	24
,, length	12 ft. 6 in.
Heating surface, fire-box	141 sq. ft.
,, tubes	1,279 sq. ft.
,, total...	1,420 sq. ft.
Superheating surface	343 sq. ft.
Grate area	26·4 sq. ft.
Working pressure ...	170 lb. per sq. in.
Wheelbase, driving ...	12 ft. 6 in
,, engine ...	24 ft. 9 in.
Weight on coupled wheels	47·6 tons
,, bogie ...	9·7 tons
Total engine weight ...	57·5 tons
Tender—	
Tank capacity ...	3,450 U.S. gallons
Fuel capacity... ...	3·5 metric tons
Engine and tender—	
Wheelbase, total ...	45 ft. 2 in.
Weight, total ...	90 tons

The 4–6–2 engine for China (Fig. 2) is a fairly large one, and is designed to inaugurate a new passenger service of heavy trains on fast schedule. This engine develops a tractive force of 26,800 lb. (at 85 per cent. boiler pressure), and, as the weight of the driving wheels is 43·15 tons, the adhesive weight is fully utilised. The frames are of the plate type. The fire-box is of steel. A superheater of 24 elements is provided. The fire-door is operated by compressed air. The valve gear is of the Walschaert type, with screw reversing gear. The pistons are of cast steel. The coupled wheels are equalised. Further particulars are given tabulated below. The tenders for these locomotives have been built in the shops of the railway company, from material furnished by the Baldwin Locomotive Works :—

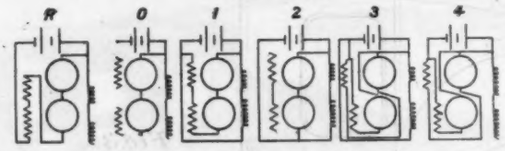
Engine—	
Gauge	4 ft. 8½ in.
Cylinders	20 in. × 26 in.
Valves	11 in. (piston)
Wheels, driving ...	66 in.
,, bogie ...	37½ in.
,, trailing ...	43 in.
Boiler barrel, diameter	68 in.
Fire-box, length ...	90⅞ in.
,, width ...	66½ in.
Water space, front ...	4 in.
,, side and back...	3½ in.
Tubes	2 in. and 5½ in.
,, 2 in. number ...	172
,, 5½ in., number	24
,, length	19 ft.
Heating surface fire-box	146 sq. ft.
,, tubes	2,343 sq. ft
,, total	2,489 sq. ft.
Superheating surface	559 sq. ft.
Grate area	41·4 sq ft.
Working pressure ...	200 lb. per sq. in.
Wheelbase, driving ...	11 ft. 8 in.
,, engine ...	31 ft. 9 in.
Weight on coupled wheels	43·15 tons
,, bogie ...	19 tons
,, trailing wheels	14·5 tons
Total engine weight ...	76·65 tons
Tender—	
Tank capacity ...	6,000 U.S. gallons
Fuel capacity... ...	8½ tons
Engine and tender—	
Wheelbase, total ...	59 ft. 9 in.
Weight, total ...	128·12 tons

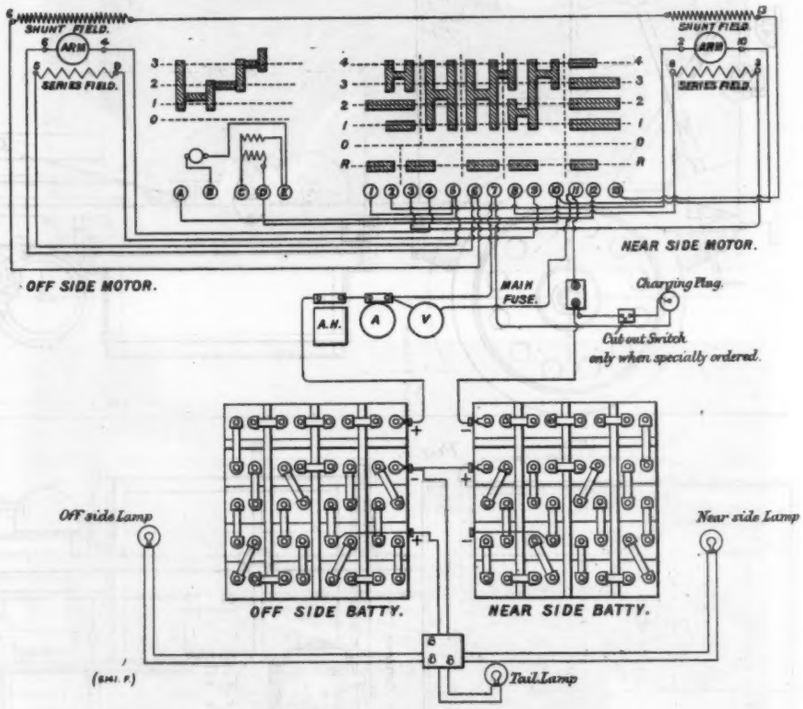
CONNECTIONS FOR ELECTRIC BATTERY WAGON.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED.

(*For Description, see Page* 446.)

Fig. 7.





NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The export call for mild steels tends to expand rather than to diminish. Makers are booked up for twelve months ahead, and are turning down valuable orders weekly. Requirements are on a "boom" level, but output falls considerably short of the demand, and producers are obliged to pass by promising contracts which would ensure busy conditions when more normal conditions are reached. Heavy contract deliveries have this week gone to France, Italy, Belgium India, and South America. Sheets and plates are almost impracurable, even at the record prices ruling for current delivery. Makers have undertaken as much work as they can reasonably promise to handle within the next six to nine months, and are refusing heavy premiums on official quotations. Another satisfactory feature of the market is the lively call for crucible steel. Up to six months ago makers were running furnaces only half-time, and were not working more than 60 per cent. of their local plant. Business booked within the past two or three months has been of such magnitude as to enable the full complement of furnaces to be put into commission. Full-time working is now the general rule, and, except through railway congestion, there are no stocks left on makers' hands. European countries, the Colonies and South America, are all heavy buyers. Indeed, export trade to-day is more robust than home business, and those firms dealing chiefly with foreign markets occupy the stronger position. Doubt as to the immediate future of the railway material departments has been set at rest by the further accession of business over the past three months. Orders for rolling-stock, springs, tyres, axles and wheels for home and export companies, have proved more than sufficient to go round. The newest departments opened by several of the foremost engineering firms have therefore fared quite as well as those formerly in existence. Nor, it is confidently felt, has the limit of trade expansion in this connection been reached, and prospects generally are viewed with satisfaction. After a steady improvement over the last nine months, the high speed steel trade has more or less come into its own, so far as a comparison with pre-war trade is concerned. Business with the United States has progressed rapidly, chiefly owing to the low rates of exchange on the other side of the Atlantic. Sheffield makers have thus been able to export at a lower selling

price than was quoted by American producers, despite the recent tariff imposed on tungsten imports. Conditions in the tool and implement section, generally, are prosperous. Makers of pliers, pincers, files and saws have on hand as much work as they can handle at the current rate of output. The raw material market fully maintains its record for persistent advances. Following the attainment by acid billets of the unprecedented figure of 26*l.* to 26*l.* 10*s.*, basic hard billets have moved up 30*s.* to 23*l.* 10*s.* and basic soft 30*s.* to 22*l.* 10*s.* Even at these high prices makers are not anxious to undertake new business. Where additional orders have been booked, a substantial premium is usually found to figure in the arrangements. There is no improvement in deliveries. The railway companies are blaming traders for holding up loaded wagons, and the traders in turn declare that journeys are still occupying abnormal periods.

South Yorkshire Coal Trade.—The opinion is strongly held in official circles that Government control will be removed from inland sales within the next four weeks. Until something of this kind happens, there is unlikely to be any considerable quantity of free coal on the market, and merchants' hands are more or less tied. At the moment the market is labouring under the effect of labour unrest. Pressure on all classes of fuel is greater than has ever been experienced. Works of all descriptions, iron, steel and engineering, and the railway companies are anxious to improve emergency stocks. A certain tonnage is also going into reserve in the corporation yards as a special precaution. Coke producers are disposing of the whole of their output. Quotations: —Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little new to report concerning Cleveland pig-iron. Conditions continue such as do not admit of extensive business, but the market fully maintains the firmness that has characterised it for some time past, and home and foreign inquiries are still heavy. Supply is considerably below needs. For home consumption, No. 1 is 212*s.* 6*d.* and No. 3 and the lower qualities are 200*s.*; while for shipment to France, Belgium and Italy the former is 217*s.* 6*d.* and the latter are 205*s.* High rates are obtainable for any odd lots of iron available for sale to other destinations abroad, and a parcel of silicious iron is stated to have realised the unprecedented figure of 297*s.* 6*d.*

Hematite Iron.—East coast hematite is firm. No. 1 is 262*s.* 6*d.*, and mixed Nos. are 260*s.* for home purposes, and quotations are 267*s.* 6*d.* and 265*s.* respectively for export to France, Belgium and Italy. Though the position in the hematite branch is still stringent, there are reports of merchants who have bought at below current rates, feeling their way in the market with a view to opening out foreign business.

Foreign Ore.—Buyers and sellers of foreign ore differ widely in their ideas as to values, and consequently business is not easy to arrange. Consumers consider 50*s.* a full figure for rubio, of 50 per cent. quality, but sellers as a rule will not name below 51*s.*, and most of them ask a higher figure. These quotations are on the 17*s.* parity freight Bilbao-Middlesbrough, and as steamers from the Spanish ore ports are being chartered at round about 37*s.*, the c.i.f. Tees value of best rubio may be put at 70*s.* to 71*s.*

Manufactured Iron and Steel.—Heavy demand for finished iron and steel does not lead to much business, manufacturers generally being too busy, and too much in arrears with deliveries to accept further work. Common iron bars are 26*l.*; marked bars, 28*l.*; steel ship, bridge and tank plates, 22*l.*; steel angles, 21*l.* 10*s.*; rivets, 33*l.*; steel boiler plates, 28*l.* 10*s.*; steel joists, 21*l.* 10*s.*; steel strip, 27*l.* 10*s.*; steel hoops, 27*l.* 10*s.*; soft steel billets, 22*l.* 10*s.*; hard steel billets, 23*l.* 10*s.*; heavy sections of steel rails, 21*l.*; and fish plates and sleepers, 26*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Little change of any kind falls to be reported in the steel trade of Scotland this week, and much activity is general. Production is not increasing to any extent, and consumers are all thirsting for larger and better deliveries, and this, too, regardless of the high prices demanded for all classes of material. Shipbuilders are still finding their operations retarded by the difficulties experienced in obtaining adequate supplies, and this hand-to-mouth order of things is far from satisfactory from their point of view. On the other hand, the steelmakers have had, and still have, their own troubles to face and every endeavour has been made to keep all their customers going. The demand for all kinds of steel is very heavy, and it goes out as fast as it is produced, but there would seem to be no limit to the amount at present required by consumers. Plate mills are being kept running constantly, as both ship and boiler plates are in great demand, while users of sectional material also keep pressing for supplies. Black sheet makers are so fully booked up that no new business can be looked at for months to come, and the demand at present is so heavy that in order to keep everybody moving the output is being spread over as many clients as possible. One or two rather tempting lines were on offer last week, but as a near date delivery was stipulated these had to be turned down. The bulk of the trade just now is for home requirements, and export business does not amount to a very large tonnage. Galvanised sheets are in good demand despite their present very high value. All round the order books are very full, and a number of firms will not even consider fresh business, in the meantime preferring to wait until arrears are wiped off. Prices are still very firm, but unchanged over the week.

Malleable Iron Trade.—Affairs in the malleable iron trade of the West of Scotland continue very brisk, and an excessive demand prevails for bar iron. The position has not eased in the slightest, and makers experience some difficulty in keeping up deliveries. Bookings have been heavy, and there is little inclination to make further commitments in the meantime, with the result that prospective buyers are finding things rather awkward at present. A goodly tonnage is being turned out, but it would require to be many times larger to meet the ever-pressing demands of consumers. Prices are strong, and show no signs of easing off, "crown" bars being quoted at 26*l.* per ton, net, Glasgow station, while the export figure is from 27*l.* 5*s.* to about 27*l.* 15*s.* per ton, net, f.o.b.

Scotch Pig-Iron Trade.—The scarcity of iron ore is at times a source of some concern to the Scotch pig-iron makers, but deliveries have been rather better during the past week, although that improvement bears no promise for the future. The result is that local producers of pig-iron are quite unable to meet the heavy demands of their customers, who all seem to want large deliveries at the same time. Foundry grades are extremely scarce and prices rule high, with No. 1 quoted at 13*l.* 10*s.* per ton and No. 3 about 13*l.* 5*s.* per ton for home consumption, while for export lots the quotations are round 15*l.* per ton for No. 1 and 14*l.* 10*s.* per ton for No. 3 quality, f.o.b. Glasgow. Hematite is the subject of a very heavy demand from the local steel works.

Wages in the Iron Trade Increased.—Mr. John M. MacLeod, C.A., Glasgow, has made the following intimation to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board. "In terms of the remit I have examined the employers' books for January and February, 1920, and I certify the average net selling price brought out is 24*l.* 1*s.* 2·11*d.* per ton." This means an increase in the wages of the workmen of 17½ per cent. on basis rates.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—The muddle in respect to the fixing of bunker prices in connection with foreign-going vessels has been the outstanding feature of the coal market. Active steps are being taken to clear up the difficulties which have arisen, and meanwhile shipowners and their agents with vessels ready to go to sea have preferred to pay current market prices rather than risk detention to their boats by waiting for supplies at the new fixed rates. On Saturday a meeting of shipowners was held, when the conditions of the new arrangements were described as ridiculous inasmuch as it was decided that vessels were only to receive sufficient bunker supplies to take them to the first port of call or coaling station where they were to obtain their further requirements at current prices. Thus a vessel going to the River Plate would only receive sufficient to enable her to reach Las Palmas, and those going to Genoa enough to reach Gibraltar. At practically all the coaling stations supplies are depleted, and vessels are already waiting for bunkers, and the result of the new bunker arrangements, if carried out, would be to further add to the congestion and increase the running expenses of shipping. It was decided to send a deputation to the Coal and Shipping Controllers on the matter, but as the arrangement is a voluntary one on the part of the coalowners it was afterwards arranged that the deputation should meet the Commercial Committee of the South Wales Coalowners' Association and place their grievances before them with a view to a satisfactory arrangement. In the meantime supplies are being allocated by the Coal Controller's representative in cases where delay would result in serious financial loss. Cargo shipments are still considerably reduced by a continued heavy inland demand which is likely to remain until after the holidays. Shipments last week amounted to 335,366 tons of which, 194,146 tons went from Cardiff, 55,324 tons from Newport, 44,601 tons from Swansea and 41,295 tons from Port Talbot. The export of foundry and furnace coke has been prohibited until further notice.

Strike at Port Talbot Docks.—Coal shipping operations have been suspended at the Port Talbot docks since last Friday night, as a result of the tippers having ceased work and thereby bringing to a standstill coal loading. It appears that the Trimming Board, which has the right to employ and discharge trimmers, recently increased the number of trimmers. The tippers have taken exception to the men appointed by the Trimming Board, and claim a preference over others in the appointment of extra trimmers. The employers have refused to comply with the demand of the tippers, and have so far declined to consider their grievances. It is, however, understood that Mr. E. Lowther, the manager of the Port Talbot Docks and Railway Company, which employs the tippers, has decided to meet a deputation of the tippers on the question.

NOTICES OF MEETINGS.

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday, April 7, at Denison House, Vauxhall Bridge-road, Westminster, S.W., when a sessional meeting will be held. "Modern Development in Civil and Military Water Supply," by Captain A. F. Girvan. The president will take the chair at 8 p.m.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Thursday, April 8, at 7.30 p.m., the Engineering Lecture Theatre, Liverpool University, Messrs. P. A. Arbeny, and H. W. Mellor, on "Design of a 40-Ton Titan Crane," being an official Association Lecture; Thursday, April 8, at 7.30 p.m., the Grammar School, Chesterfield, Mr. E. Nicholson, M.I.S.I., on "The Destructive Distillation of Coal."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 9, at 7.30 p.m., at 39, Victoria-street, S.W. 1, Lecturette, "The Development and Manufacture of the Thermionic Valve" (slides and demonstrations), by Mr. A. H. Howe, Associate Member.

INDUSTRIAL LEAGUE AND COUNCIL.—Southwark has formed a local branch of the League, and one of the most promising indications of the success which is bound to attend the efforts of promoters in that area is that the responsible representatives of Labour, as well as big employers in the district, have entered wholeheartedly into the movement.

CONTRACTS.—Messrs. Perman and Co., Limited, 82 and 83, Fenchurch-street, London, E.C. 3, state that they have just booked a contract or six 180-h.p. British Kromhout marine oil engines comprising three twin-screw sets for concrete vessels which are now being constructed. The vessels carry about 1,000 tons deadweight of cargo; their dimensions are: Length, 180 ft.; breadth, 35 ft.; depth, 19 ft.; draught, 15 ft.

MANCHESTER ASSOCIATION OF ENGINEERS.—The annual meeting of this association was held on Saturday, March 27, when it was reported that the membership was progressing considerably, the number on the rolls amounting to 777. Mr. Henry Pilling, M.B.E., M.I.Mech.E., of Messrs. Galloways, Limited, was elected president in the place of Mr. Harold F. Massey, who retired according to rule. Subsequently Mr. Pilling read a paper on "Uniflow Engines."

PERSONAL.—The headquarters office of the Central Commercial Department of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, have been removed to new offices situated at No. 3, Woodstock-street, Oxford-street, W. 1, to which address all correspondence should be sent in future. Sir W. G. Armstrong, Whitworth and Co., Limited, are preparing to add civil engineering and public works contracting on a large scale to their extensive enterprise. This Civil Engineering Department has now been formed, under the control of Mr. Robert H. Mackenzie.—Messrs. J. B. Guthrie and Son, 30, St. Mary Axe, Leadenhall-street, E.C. 3, state that they have taken into partnership, Mr. Walter John Francis Burgess, who has been associated with their firm for upwards of fourteen years.

REBUILDING BELGIUM.—The Department of Overseas Trade has been informed by a representative of the Belgian Ministry of the Interior that the great problem of the reconstruction of the devastated areas is now being undertaken by the Belgian Government. Some idea of the gigantic task confronting the Belgian authorities may be obtained from the statement of the Ministry of the Interior's representative, that there are some 1,104 churches and between 100,000 and 120,000 houses to be built in the devastated regions. For this purpose a large amount of building material will be required, especially brick-making machinery, metal girders, window frames, standardised locks and keys, paint, stained glass, lead piping, pumps, bedsteads and bedding, and large quantities of nails, screws and bolts. British firms who are in a position to supply any of the above-mentioned articles should apply to the Belgian Ministry of the Interior, Brussels.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—In conformity with the Articles of Association providing for rotation of office on the Main Committee, whereby one-third of the nominees retire each year, the councils of the technical institutions who founded the association have now made their new nominations, which take effect at March 31. The Main Committee will then be constituted as follows: Sir Archibald Denny, Bart. (chairman); Sir Maurice Fitzmaurice, C.M.G. (vice-chairman); Sir John Aspinall, Sir Arthur Duckham, K.C.B., Sir William Ellis, G.B.E., Sir William Matthews, K.C.M.G., Mr. Alexander Ross, and Dr. W. C. Unwin, nominated by the Institution of Civil Engineers; Sir Henry Fowler, K.B.E., Sir Vincent Raven, K.B.E., and Dr. William H. Maw, nominated by the Institution of Mechanical Engineers; Dr. Arthur Cooper, Mr. M. Mannaberg, and Mr. Benjamin Talbot, nominated by the Iron and Steel Institute; Sir W. E. Smith, C.B., and Sir Thomas Bell, K.B.E., nominated by the Institution of Naval Architects; Colonel R. E. Crompton, C.B., Sir John Snell, and Mr. C. H. Wordingham, C.B.E., nominated by the Institution of Electrical Engineers; Mr. F. W. Gilbertson, and Mr. F. R. Davenport, co-opted by the nominated members to represent the Federation of British Industries; The Hon. Sir Charles Parsons, K.C.B., Sir Richard Glazebrook, K.C.B., and Sir Robert Hadfield, Bart., co-operated by the nominated members.

LOCOMOTIVES FOR RAILWAYS IN NORWAY AND CHINA.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

(*For Description, see Page* 448.)

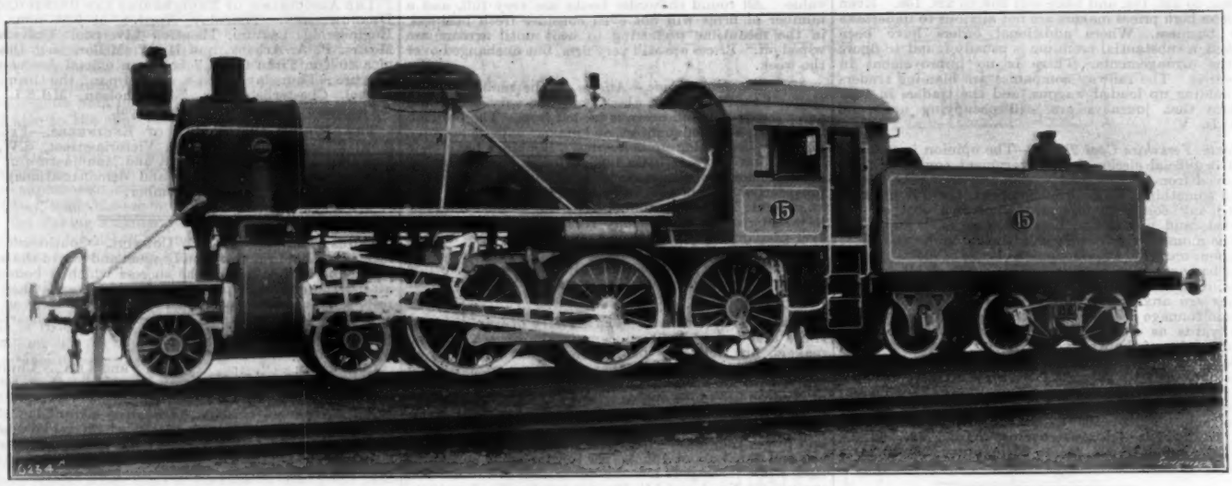


FIG. 1. 4-6-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE NORWEGIAN TRUNK RAILWAY.

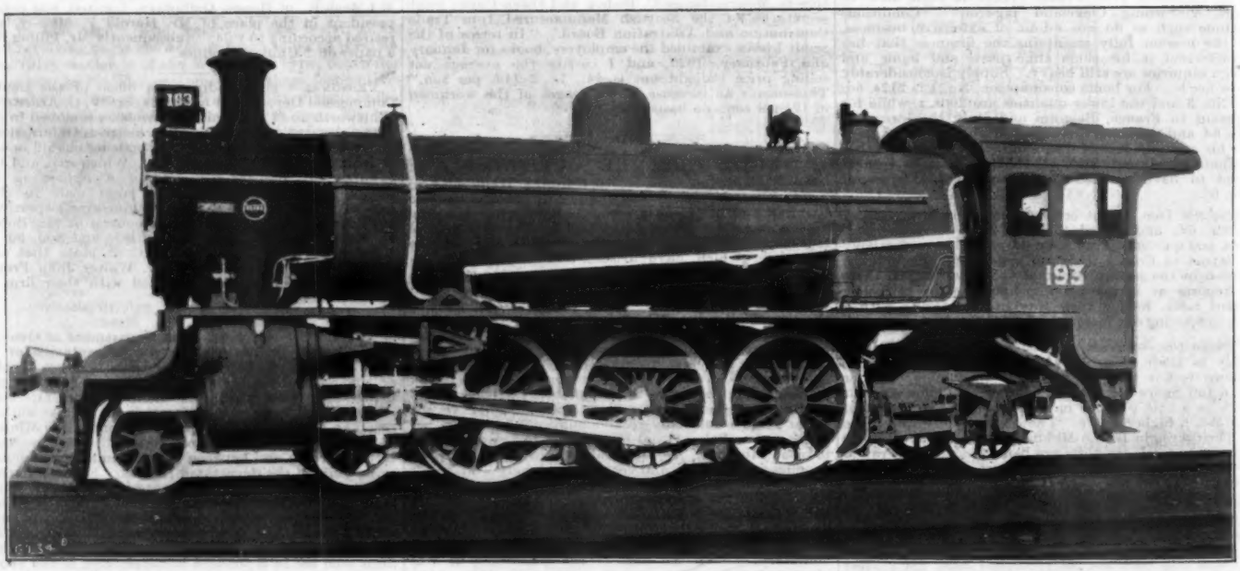


FIG. 2. 4-6-2 TYPE LOCOMOTIVE FOR THE PEKING-MUKDEN RAILWAY, CHINA.

BOROUGH POLYTECHNIC INSTITUTE.—The annual exhibition of students' work at this Institute, which is situated in the Borough-road, London, S.E. 1, was held on Saturday, March 27. The laboratories and workshops in all departments were open to the inspection of visitors, the machinery being in most cases in motion; demonstrations were given at intervals. There was a good display of work by both day and evening students.

UNIVERSITY COLLEGE, LONDON.—The annual report of University College has just been issued. The total number of students for the session 1918–19 was 2,048, an increase of 977 on the previous year. This increase took place after the armistice and mainly in January, 1919, and consisted almost exclusively of ex-service men. Arrangements were made whereby the ex-service men who resumed work in January, 1919, were enabled to complete a full session's work by the beginning of August, and most of them succeeded in so doing. The total revenue of the college for the year 1918–19 was 75,781*l.*, of which 26,304*l.* was from fees. The total expenditure was 77,824*l.* The deficit arises from the increase in salaries that has become necessary, and generally from the increased cost of running the college. The student body included 127 members of the American Expeditionary Force and 71 members of H.M. Overseas Expeditionary Forces. It also included 263 post graduate and research workers.

THE DANISH AVIATION COMPANY.—The Danish Aviation Company, which has been carrying on preliminary work for about 2½ years, now hopes to commence operations very shortly. In the meantime negotiations have been carried on with aviation companies in England, Holland, Germany, Norway and Sweden, for co-operation in working and to make the necessary arrangements with respect to the various routes to be covered. Amongst the routes which commend themselves especially is that between Copenhagen, Esbjerg, Amsterdam and London, or, should the decree of the Entente that no foreign machines may fly over German territory be withdrawn, the route preferred would be Copenhagen, Hamburg, Amsterdam, London, Danish aeroplanes travelling as far as Hamburg and Dutch aeroplanes continuing the journey to London. In a similar manner the Copenhagen-Berlin route would be arranged, German machines taking up the traffic at Warnemünde. The company will pay special attention to postal services and the Danish postal authorities are taking considerable interest in the scheme.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION.—The annual general meeting of the association took place at the offices of the Association, Kingsway, W.C. 2, on Thursday, March 18. The chairman, Mr. W. C. Smith, reviewed in detail the work of the association during the year as recorded in the report, particularly noting the excellent work done by certain committees, as for example, the Overseas, Education, Standardisation and Traffic Committees. On the subject of research, he said that the work of the Electrical Research Committee was at present somewhat restricted through lack of funds. Given the necessary funds, and the consequent Government grant, existing researches could be carried on expeditiously, and much work in contemplation could be put in hand. The council had given very careful consideration to the subject, and had arrived at the conclusion that collective research was not only desirable, but necessary in the interests of the industry, if they were even to keep pace with other countries already well organised for research.

MACHINERY OF H.M. RIGID AIRSHIPS R33 AND R34.

CONSTRUCTED BY THE SUNBEAM MOTOR CAR CO., LIMITED, ENGINEERS, WOLVERHAMPTON.

(*For Description see Page* 433.)

Fig. 1

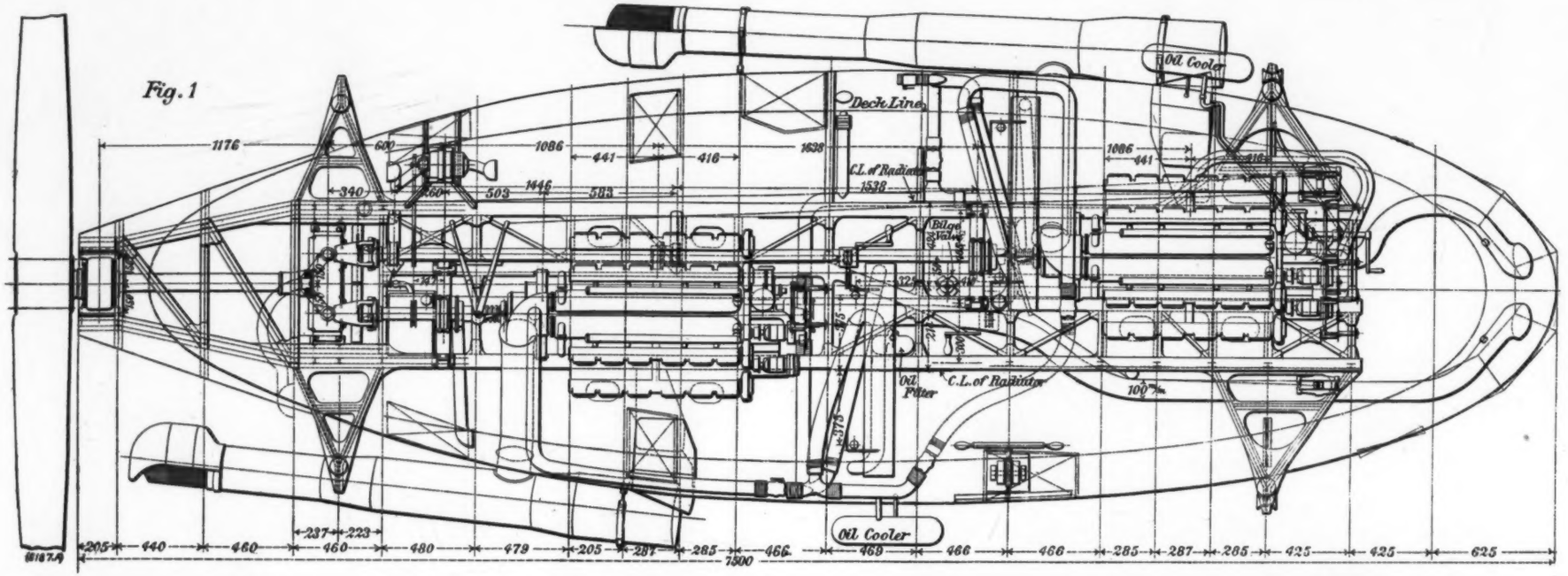


Fig. 2.

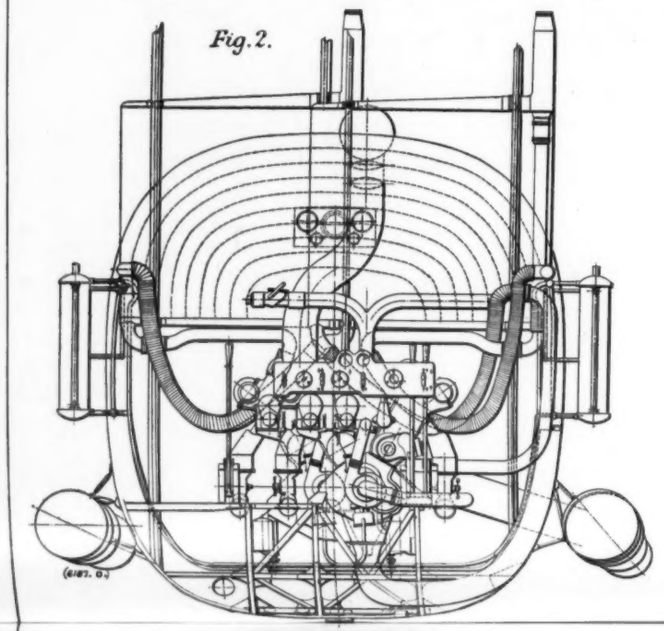


Fig. 3.

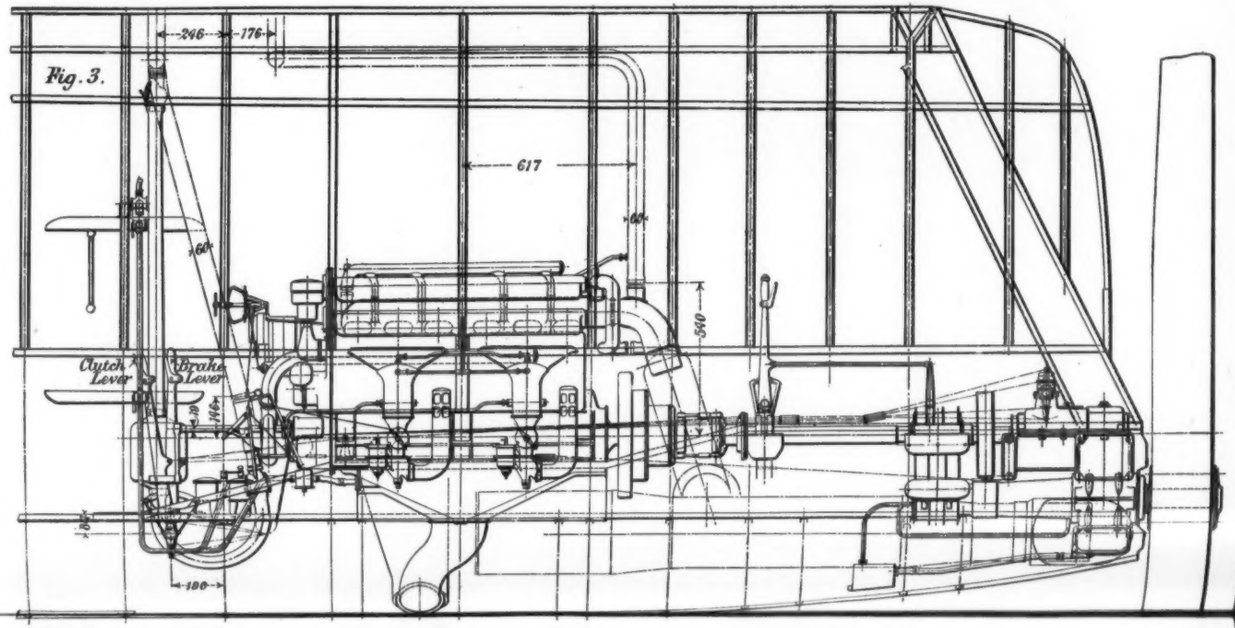


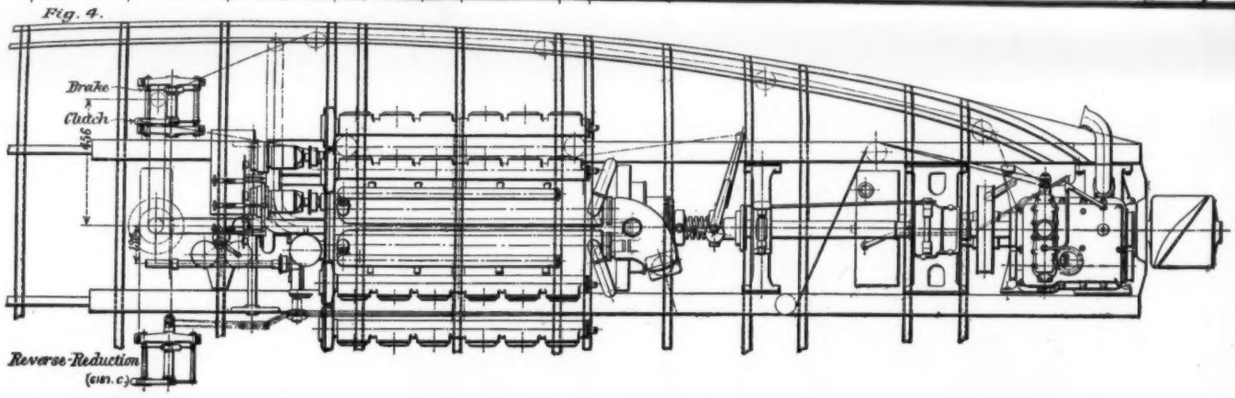
Fig. 4.

TABLE OF DIMENSIONS AND DATA.

TABLE OF DIMENSIONS AND DATA.

Length of ship	647 ft.
Maximum diameter	78 ft.
Total weight, empty	32 tons.
Total weight, fully loaded	60 tons.
Gas capacity	2,000,000 cub. ft.
Total B.H.P. of engines	1,350.
Maximum revolutions of engines	2,100 r.p.m.
Cruising revolutions of engines	1,800 r.p.m.
Ratio of propeller to engine revolutions	1 : 3·86.
Petrol consumption :	
At full load near ground	71·5 galls. per hour.
At full load at 5,000 ft.	59·5 do.
At cruising load near ground	47 do.
At cruising load at 5,000 ft.	39·5 do.
Diameter of wing and forward propellers	17 ft.
Diameter of aft car propeller	19 ft. 6 in.

Fig. 4.



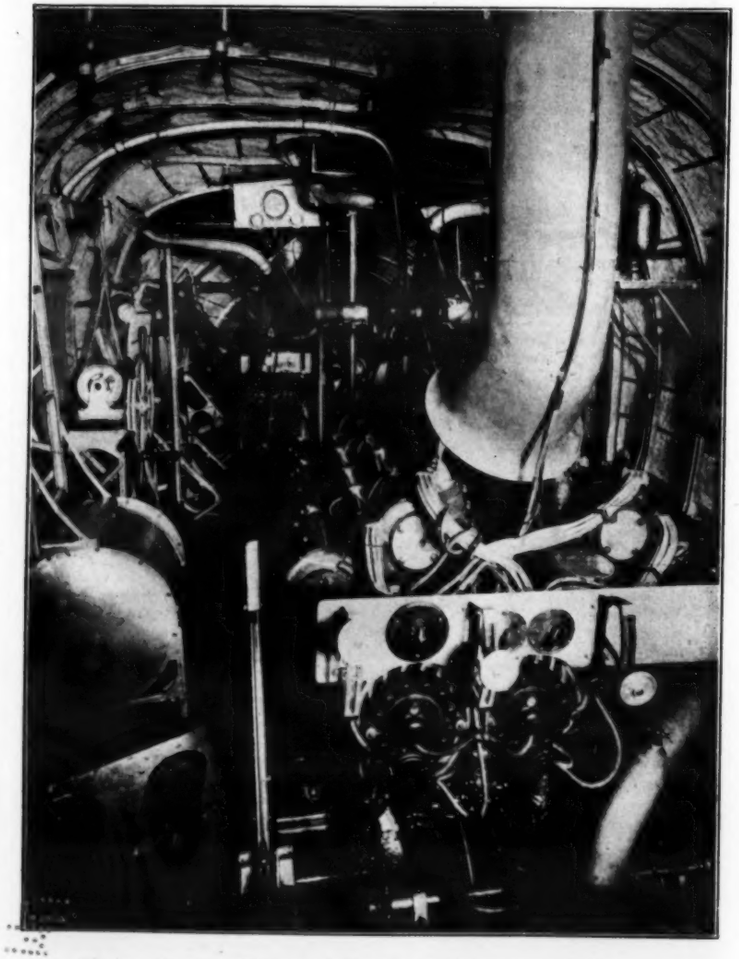


FIG. 5. INTERIOR VIEW OF AFTER CAR, LOOKING AFT. R 33.

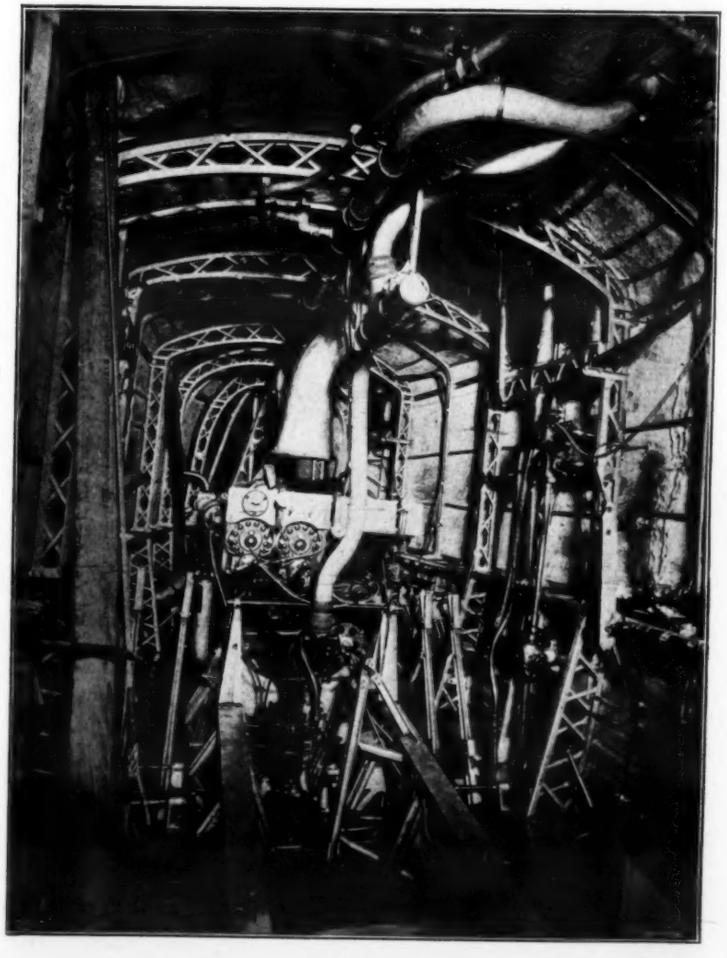


FIG. 6. STARBOARD WING CAR, LOOKING AFT. R 33

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: R. F. Satchell, 86, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements, J. S. Allan, 18, Broadway, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 3 0
For Canada—	
Thin paper copies	£2 18 6
Thick " "	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick " "	£3 7 6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3883 and 8596 GERRARD.

CONTENTS.

	PAGE
The Machinery of H.M. Airships R.33 and R.34 (*Illus.*)	433
The Armstrong Shipyard (*Illus.*)	434
The Institution of Naval Architects	437
The Chaine Helice (*Illus.*)	441
An Electric Rivet Heater (*Illus.*)	441
Machine Vice for Repetition Work (*Illus.*)	441
The Schneider 155-m.m. Howitzer (*Illus.*)	442
The Production of Power from Blast Furnace Gas (*Illus.*)	443
70-cwt. Electric Battery Tipping Wagon (*Illus.*)	446
Locomotives for Norway and China (*Illus.*)	448
Notes from South Yorkshire	448
Notes from Cleveland and the Northern Counties	449
Notes from the North	449
Notes from the South-West	449
Notices of Meetings	449
The Royal Corps of Naval Constructors	451
Test of Materials	452
Positive Rays (*Illus.*)	453
Notes	455
Literature	456
Books Received	457
Industrial Notes	457
The Effect of Circular Holes in the Distribution of Stress in Tension Members (*Illus.*)	458
"Aeroplane Structures"	458
Development of Metal Construction in Aircraft	458
"The Cammellaird-Fulgar Engine"	458
University College Students	458
The Relation of Employer and Employee	458
Notes on Our Economic Position as a Shipbuilding Country (*Illus.*)	459
Further Notes on the Dimensions of Cargo Steamers (*Illus.*)	461
The Stabilisation of Ships by Means of Gyroscopes (*Illus.*)	462
The Effect of Size upon Performance of Rigid Airships (*Illus.*)	464
On the Polishing and Etching of Zinc for Micro-Examination	466

With a Two-Page Plate of the MACHINERY OF H.M. RIGID AIRSHIPS R.33 AND R.34.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. New higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price will date from and include the present issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d., post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 449.

ENGINEERING.

FRIDAY, APRIL 2, 1920.

THE ROYAL CORPS OF NAVAL CONSTRUCTORS.

ALL gratefully acknowledge that never in the world's history has the function of the British Navy been so completely vindicated as during the past war. We look to our Navy to "be a safeguard unto our most gracious Sovereign . . . and a security for such as pass on the seas upon their lawful occasions." Never has this duty been so faithfully performed as in the recent years. We are all ready enough to offer unstinted praise to the man behind the guns, and to the tactician who brings about a naval "success" by his skill and courage. How many in this country go any further than this in their enthusiasm, and ever think of the men to whom the possibility of such a success is primarily due—the designer of the ships? If we could get at the real thoughts of people on receiving news of a naval action, we would certainly find hearts aglow at the military aspect of the event, but the excitement would probably subside before it was realised that it was due to the design, as well as to handling, of the vessels, that such a result had been compassed. The Navy is the user of tools put into its hands, the tools being the ships devised and planned by the Royal Corps of Naval Constructors. To this corps then is due equal credit with the Navy itself, for the proud position which we as a naval Power maintain to-day in the world.

Seldom is it recognised how much unobtrusive work this keen body of capable men perform in their country's service. Some idea of it may be gleaned from the proceedings of the Institution of Naval Architects, in whose circles alone is adequate credit given to it. The paper read before that Institution last year by Sir P. Watts, formerly Director of Naval Construction, and that by Sir Eustace T. d'Eyncourt, who now holds that position, tell something of the state of our Navy at the outbreak of war and of the amount of work done during the war. At the time of the founding of the Royal Corps of Naval Constructors the fastest armoured ship in the Navy had a sea-going speed of 15 knots. The beginning of the war saw the completion of the Queen Elizabeth with 25 knots, while evolution since the date of that vessel has culminated in the Hood, which has just completed trials at 32 knots. This vessel was described in the paper read by Sir E. T. d'Eyncourt last week before the Institution of Naval Architects, and, with its 42,000 tons displacement and 150,000 h.p., constitutes the most advanced example of warship design extant.

As the designers for the Navy, the Royal Corps of Naval Constructors were responsible between 1910 and 1914 for 13 battleships completed, 6 battle cruisers, 23 light cruisers, 100 destroyers, 14 submarines and numerous auxiliaries. This in itself is a good record, especially as it enabled us to keep so far ahead of foreign competitors. In every case on our own lines of development we were to the fore in design. But under the stimulus of war the work expanded in an astonishing degree, not adequately realised by the general public. Compared with the four years named above, the succeeding four, between 1914 and 1918, showed the following results:—Twelve battleships completed, three battle cruisers, three large light cruisers, 34 light cruisers, 24 flotilla leaders, 207 destroyers, 146 submarines, eight aircraft carriers, to say nothing of monitors, auxiliaries, &c. Airships, too, should not be omitted, the design of which came under the Royal Corps in 1917. All this work, except the latter, might, of course, have been mere repetition of pre-war designs, but throughout design has kept pace with the lessons of the war. At the outbreak of war we had no 15-in. guns in service. During the war no less than 100 were added to our battle fleets, compared with Germany's 16. Altogether we made a net addition of 118 heavy guns to the battle fleet during the war, compared with Germany's 72, and the added weight of broadside amounted in our case to 226,000 lb., compared with Germany's 77,500 lb. Between 1915 and 1918 we completed more naval tonnage than in the whole of the previous 25 years, adding something like 2,000,000 tons at a cost which amounted to between four or five times the total cost for construction during the previous four years.

When it is considered that all this work involved new designing, often along untrodden paths, under the stress of war, when every effort had to be made to make the promptest use of lessons learnt in service, it will be recognised that an enormous strain must have been thrown on the staff to render possible such an unprecedented achievement. From an engineering point of view the work is one of immense magnitude. It is impossible for the outsider to appreciate fully the intricacies of design required in modern vessels of war. The training of our New Army, the manufacture of munitions, the organisation of the nation—all these were advertised and took hold of the popular mind. But the quiet work of the designers of the means of carrying on the effective work of the silent service was done behind closed doors. None of their achievements was allowed to get into the papers at the time, and comparatively few since.

When we think of the interests at stake, and the ever-present possibility that our enemies might be forestalling us in some unthought of direction, the enormous responsibility of those in charge of our designing work may be realised to some degree. Rumour at times brought word of wonderful developments abroad equalling or surpassing ours, but it may safely be claimed that we anticipated every German move by going one better. Even in times of peace the burden on the shoulders of our naval constructors is no light one. But then there is some sense of knowledge that the work is being done in the light—possibly dim at times—of developments elsewhere, nor is there then the same strain of working against time. During war this light is extinguished, while the working strain is screwed up to the highest tension by the knowledge that success is largely dependent upon being early in the field with new ideas. How great has been the success in this direction can scarcely be reduced to paper, but the fact that these vessels have so well come up to the Admiralty's expectations is a proof of the soundness of the policy of insisting on the highest qualifications for the naval designing staff. At the recent meeting of the Institution of Naval Architects, Commander Land, of the United States Navy, paid a well-merited tribute to our naval constructors, pointing out that the confidence with which our officers and crews took over in war time absolutely new ships after a minimum of trials was sufficient evidence in itself of the thoroughness and reliability of our designing staff.

It will be granted that a corps which has served the country so well as the above story tells should rank high among our national assets. It is recruited from the ablest of our young men, and it is so safeguarded that only the able can gain entrance to it. Yet we find that in comparison with its work and responsibilities no acknowledgment of an adequate nature is granted to those who compose it. The

salaries in most cases are less than moderate, and pay now remains much as it was in 1910, before the spending power of money was so greatly reduced. This matter we are glad to know is now receiving attention. The other services have had their scales greatly improved lately, and it is to be hoped that steps may be taken to raise the status and the pay of this corps to something commensurate with the immense responsibilities it shoulders. Its position and character is somewhat anomalous, as it is composed of a body of civil servants engaged on naval service. We trust the work of the Treasury in systematising the conditions of Civil Service will not result in the exceptional character and claims of this corps being overlooked, and that its unique connection with the Navy may not be tampered with. The corps is an advanced technical body, and in any rearrangements full recognition should be given to this important fact.

TESTS OF MATERIALS.

PROBABLY 90 per cent. of the tests of our materials of construction are made merely with the object of making sure that steel or other metal proffered by the makers is substantially identical in its properties with what has previously been found to prove satisfactory in service. Where the methods of manufacture and the chemical composition of such products is unaltered, fairly simple tests suffice in general, to ensure this, even if they are conducted in a somewhat rough and ready way. Indeed, the objection sometimes taken against the rapidity with which tests of this kind are made at makers' works is, perhaps, not altogether reasonable, since such tests do not really aim at accurately establishing the physical properties of the material but merely to show that it is of the kind and quality fixed by the specifications. As Professor Unwin pointed out in his admirable presidential address delivered to the Institution of Civil Engineers in 1911, an empirical factor enters into the selection of material for a given end, and into the fixation of the safe admissible stress on it. A prolonged past experience in short, has shown that certain qualities of steel are satisfactory for certain purposes, and the prudent engineer will hesitate before substituting for them even a material which ordinary tests may indicate as superior in quality.

The engineer of a generation or so ago found tests of the above kind sufficient to meet most of his needs. It is true, nevertheless, that mysterious failures did occur and led to the introduction into specifications of clauses prescribing or proscribing certain methods of manufacture. Such clauses were a frequent source of dispute between engineers and makers, as the latter claimed that the engineer should merely specify his requirements and not concern himself with means adopted to attain them. This protest would have been reasonable enough were it not that laboratory tests had repeatedly proved inadequate *per se* to ensure the suitability of metals for particular purposes. Thus some years ago much trouble arose from the replacement in Muntz metal of furnace-refined copper by electrolytic copper, and to secure reliable material it became necessary accordingly, to bar the use of the latter in spite of the protests of makers that they could satisfy with electrolytic copper all the requirements as to the strength and ductility set forth in the specifications for furnace refined copper.

In general, it may be said that every new material has to stand the test of actual use before we can be certain as to its real utility. Some nickel steels, for instance, failed lamentably in service in spite of the fact that in laboratory tests they showed an ultimate strength of 40 to 45 tons per square inch, combined with an elongation of 30 to 45 per cent. on 4 in., whilst in notched bar tests, which have been claimed as of themselves sufficient to establish the reliability of materials of construction, these particular nickel steels appeared to be 50 per cent. to 60 per cent. better than a good 28 to 30 ton carbon steel. The introduction of the modern large, high-speed turbine has given rise to a demand for steels of greater strength than that possessed by our well-tried mild steels containing carbon only. In some large impulse turbines as built to-day, the blade tip speed is as much as 1,000 ft. a second. This figure has, of course, been very substantially exceeded in de Laval turbines, but the wheels in this case are of small size, and it is universally recognised that it is impossible to secure as high a quality in large masses of steel as in smaller ones.

With large turbines with these high blade speeds, it has been necessary to make use of certain of the newer alloy steels, and it cannot be said that the results have been uniformly satisfactory. These high speed wheels have failed both here and in America, sometimes with disastrous results, and though bad design has no doubt often been a contributory factor to such mishaps, there is good reason for believing that in other cases the fault has lain with the material used. It was no doubt considerations of this kind that led the British Electric and Allied Manufacturers' Association in 1918 to appoint a committee to investigate the properties of four steels covered in the "Beama" specifications, and to advise as to how the present reception tests might be modified or extended. The committee consisted of Dr. W. H. Hatfield, the well-known chief of the Brown-Firth research laboratories, and of Mr. H. M. Duncan and Mr. A. D. C. Parsons. The results of this inquiry are set forth in a paper by Dr. Hatfield and Mr. Duncan, which was read before the North East Coast Institution of Engineers and Shipbuilders on Friday, March 19.

The tests made included tensile tests, torsion tests, notched bar tests of various kinds, in addition to bending tests by the Arnold and Sankey machines. Further tests were also made with alternating shocks on the Stanton machine. In this test notched bars are broken by impact; being turned through 180 deg. between successive blows. Hardness tests by the Brinell method and by the scleroscope were also included. These latter tests are perhaps better adapted to the securing uniformity of a product than to furnishing directly data as to the adequacy of a material for a novel purpose.

The results obtained in these tests are summarised in the following Table I:—

TABLE I.

—	Turbine Discs.				Shafts.				
	R.L. 6018A.		R.L. 6018B.		R.L. 5894.		R.L. 6206.		
	Sample 1.	Sample 6.	Sample 1.	Sample 6.	Longi-tudinal.	Trans-verse.	Longi-tudinal.	Trans-verse.	Radial.
Carbon, per cent.	0·374		0·370		0·28		0·37		
Manganese, per cent.	0·670		0·596		0·51		0·74		
Silicon, per cent.	0·108		0·154		0·12		0·11		
Sulphur, per cent.	0·035		0·041		0·032		0·030		
Phosphorus, per cent.	0·052		0·049		0·035		0·026		
Chromium, per cent.	—		—		—		—		
Nickel, per cent.	—		—		0·19		0·34		
E.L., tons per sq. in.	8·08	8·66	13·74	5·12	11·8	8·0	14·00	12·81	12·41
Y.P., tons per sq. in.	16·35	13·0	16·05	13·39	13·7	10·8	16·94	16·35	17·14
M.S., tons per sq. in.	32·9	29·03	31·5	28·2	28·4	25·6	36·78	34·36	35·16
Elongation, per cent.	28·0	32·0	28·5	33·0	33·5	22·5	27·0	18·0	23·5
Red. of area, per cent.	45·8	54·6	47·15	55·8	53·4	33·5	41·87	30·55	36·33
Shear stress at E.L., tons per sq. in.	10·4	8·0	10·97	8·37	9·1	9·5	10·34	10·15	10·24
Appar. max. shear stress, tons per sq. in.	35·7	33·3	34·3	32·6	31·7	32·4	34·17	33·06	33·99
Prob. actual max. shear stress, tons per sq. in.	26·8	25·0	25·7	24·4	23·7	24·3	25·63	24·8	25·5
Degrees Twist	540	702	490	760	508	533	308	204	354
Izod, ft.-lb.	4, 5, 4	5, 5, 5	5, 5, 5	5, 5, 5	16, 20 & 20·5	11·5, 15 & 12·5	8, 15, 15	12, 7, 14	12, 12 & 10·5
Charpy, ft.-lb.	3·5	4·0	4·0	3·5	6·9	8·0	8·4	8·0	10·1
Fremont, kg.	2·0	2·0	2·0	2·0	7·0	1·0	—	—	—
Fremont angle, degrees	6·0	5·0	5·0	6·0	—	—	—	—	—
Fremont, ft.-lb.	—	—	—	—	52·5	7·23	—	—	—
Stanton Blows	553	556	597	471	956	629	1,142	659	781
Arnold reversals	230, 196	340, 294	314, 176	354, 308	366, 512	302, 296	386,428	88, 150	170, 262
Sankey alterns	11·3	25·0	9·1	15·0	—	—	21·2	6·9	6·3
Sankey, max. B.M.	58·0	51·5	54·75	51·0	38·0	17·0	56·0	56·6	55·4
Sankey, ft.-lb. energy	985	1,860	730	1,160	2,600	1,290	1,830	615	540
Bend, degrees	175	180	180	180	—	—	—	—	—
Brinell imp. mm. (1,500 kg. load)	3·7	3·95	3·75	4·0	3·8	4·1	3·55	3·6	3·6
Brinell Hardness No.	135	118	131	114	128	109	147	143	143
Shore hardness No.	29	27	30	27	20/21	19/20	27	28	28

TABLE II.

R.L. 6311 Samples.	Treatment.	E.L.	Y.P.	M.S.	E.L. Per Cent.	R/A Per Cent.	Izod Ft.-Lb.	Stanton Blows.	Sankey. Bends.	Sankey. Max. B.M.	Energy Ft.-Lb.	Brinell No.
1	850 deg. C. for 2 hours and air cooled	—	21·1	34·4	34·0	56·9	38½ 30 31	1,341	30·2	60·0	2,760	156
2	850 deg. C. for 2 hours and slowly cooled	—	19·1	33·4	32·5	52·2	24 24 25	920	35·6	54·5	2,840	144/146
3	950 deg. C. for 2 hours and air cooled	16·7	19·9	37·4	27·0	47·1	32 30 29	1,263	32·9	60·0	3,020	151/160
4	950 deg. C. for 2 hours and slowly cooled	15·8	16·9	33·9	31·0	47·1	20 21 20½	638 faulty	11·2 18·4	56·0 57·5	980 1,630	151
5	1,050 deg. C. for 2 hours and air cooled	15·4	19·7	37·4	29·0	49·7	70 31 39 (piped)	1,497	26·4	60·5	2,420	151/160
6	1,050 deg. C. for 2 hours and slowly cooled	13·8	16·3	32·5	29·0	49·7	14, 15, 13	660 faulty	20·9	56·6	1,830	146
7	1,300 deg. C. for 2 hours and air cooled	17·7	20·0	37·3	24·0	36·3	15, 15, 19 (faint pipe)	1,497 faulty	19·8	61·5	1,900	151/160
8	1,300 deg. C. for 2 hours and slowly cooled	15·2	16·3	33·0	30·0	44·5	14, 13 13	896	19·2	56·5	1,680	134
9	900 deg C. for ½ hour, air cooled, followed by 600 deg. C. for 5 hours and slowly cooled	19·7	20·5	34·3	32·0	56·9	29, 32, 32	1,202	29·1	56·75	2,500	134/160
10	900 deg. C. for ½ hour, air cooled, followed by 680 deg. C. for 5 hours, and slowly cooled	16·94	18·12	31·55	39·0	62·57	32, 33, 36	640	34·9	54·1	2,850	135
11	900 deg. C. for ½ hour, air cooled, followed by 750 deg. C. for 5 hours and slowly cooled	17·2	17·7	30·5	40·0	64·7	32½, 36, 41	690	30·4	55·1	2,580	137

Slow coolings took approx. 7 hours down to 200 deg. C. in 2, 4, 9, 10, and 11. In (8) no record taken.

Micrographs also taken showed a marked difference in the properties of specimens cut from opposite sides of the disc RL 6018. This, it appears, had been heat treated, and much more drastically on one side than the other. The differences in the specimens cut axially, transversely and radially from the shaft RL 6206, are also noteworthy. The Stanton, Arnold and Sankey tests show that the toughness of the material was far greater in the specimens taken axially than in the other directions.

Another kind of turbine steel very thoroughly examined had the following composition:—

	Per Cent.
Carbon	0·36
Manganese	0·64
Silicon	0·18
Sulphur	0·044
Phosphorus	0·032
Nickel	0·08
Chromium	0·08

Bars of this steel 1½ in. diameter by 8 in. long, were heat treated and then tested with the results shown in the annexed Table II.

The interpretation of these results is not without difficulty, nor is it certain that short duration tests of this kind will give reliable data for estimating the behaviour of the material in service. Even with the relatively moderate steam temperatures hitherto adopted in power station practice studs have been found to become brittle after two or three years service, and some short time test, sufficient to be able to predict the effects of a long continued soaking at moderate temperatures would be a great boon to those responsible for the design and operation of our power plants.

As is usually the case the committee found great difficulty in obtaining specimens of material which had failed in service. Only one disc and one shaft were submitted to them. Specimens cut axially from the disc showed lack of ductility, and to this its failure is attributed. The defective shaft showed evidence of slag inclusions.

In respect to the matter of recommending additional tests, the Committee seem inclined to favour Captain Sankey's bending test. This has certainly behind it the prestige of generations of successful use since the Sankey machine merely renders quantitative the type of test relied on by smiths and other users of iron since probably prehistoric times. The Arnold machine also seems reliable, and if the circumstances should involve the use in turbine details of sharp re-entering angles, the Committee consider that the Stanton test should be serviceable. The notched bar test is not favoured by them, and they seem to agree with the view frequently expressed that it is too drastic, and that its adoption would accordingly involve the rejection of much really serviceable material. In this connection, however, it may be mentioned that at the International Congress on the Testing of Materials held at New York in 1912, M. Derihon stated that this test had been adopted at the steel works with which he was connected, and though at the outset 20 per cent. to 30 per cent. of the output failed to pass the proof, yet by improvements in processes of manufacture this figure had ultimately been reduced to less than 3 per cent.

POSITIVE RAYS.

On the afternoon of Saturday last, the 27th inst., at the Royal Institution, Professor Sir J. J. Thomson, O.M., Pres.Roy.Soc., delivered the concluding lecture of his course on the above subject.

Referring again to the substance which appeared in some positive-ray photographs with an apparent atomic weight of 3·5, Professor Thomson said that he had never found this line with an intensity indicating the presence of any large quantity of "3·5" amongst the gas under examination. It would therefore be very difficult to isolate it by any method less delicate than positive-ray analysis, which in this regard was far superior not only to chemical but also to spectroscopic methods of analysis. To get results with these it was necessary to have at one's disposal far greater quantities of the substance under examination than sufficed with the positive-ray method. The latter was, he said, very good at starting hares, but the "hares" were so evasive that it was difficult to catch them by other methods.

In his last lecture, he had said that there was no doubt that the body with an apparent atomic weight of 3 was in some cases a molecule consisting of three atoms of hydrogen. There were, however, some indications that there was another source of this line. This line was found on some plates with small differences from its usual appearance, and he thought, therefore, that the possibility should not be excluded of the line being also attributable to another carrier than the molecule H_3.

The late Lord Rayleigh had shown that it was possible to deduce the nature of a substance from the breadth of the lines in its spectrum. The molecules of a gas were in constant motion due to thermal agitation. When a gas was examined in the spectroscope some of the molecules responsible for a line were moving towards the observer and others away from him, and we thus got a Döppler effect. The wave-length of light emitted by particles moving towards the observer were shortened and, conversely, that of the light emitted by particles moving away from the observer was lengthened. The line observed in any spectrum was accordingly not confined to light of a single wave-length, but was really a band spread out on each side of the line, representing the pure wave-length of the light which would be emitted by the radiating particles if they were all at rest. The faster these particles were moving the wider the band into which the pure line of their spectrum was broadened. In any gas the average speed of an atom was proportional to the square root of its atomic weight. The lighter atoms in a mixture of gases moved, therefore, faster than the heavier ones, and the lines of their spectrum were accordingly broader. Lord Rayleigh had worked out mathematically the relationship between the broadening of these spectral lines and the average speed at which the particles responsible for them were moving. If this speed were known, in addition to the temperature of the gas, we could deduce therefrom the atomic weight of the particle responsible for a line seen in the spectroscope.

M. Fabry had applied this method to determining the atomic weight of the source of a line which had a great interest for astronomers. This line was seen only in the spectra of nebulæ, and was attributed to an element which had been named nebulium. No terrestrial source of nebulium was yet known. M. Fabry had applied Lord Rayleigh's method to find the atomic weight of nebulium. He chose a nebula, of which the spectrum showed lines both of hydrogen and of nebulium. From the broadening of the hydrogen lines he deduced, by Lord Rayleigh's formulas, the average speed of the molecules of hydrogen, and, knowing the atomic weight of this element, he found the temperature of the nebula. Then, knowing this temperature, and measuring the breadth of a nebulium line, he was able to deduce the atomic weight of the element responsible for it. This turned out to have the value 3, or the same as that of the particle responsible for the "3" line in positive-ray photographs.

Undoubtedly, in many cases the molecule H_3 was responsible for this line on positive-ray plates, but there were differences in the appearance of this line which seemed to indicate that it might be derived from two sources. He did not know whether or no, one of these was nebulium.

There were some other lines in positive-ray photographs, the origin of which had not yet been traced to known elements. One corresponded to a particle with an apparent atomic weight of 1·6. This, he believed, was due to a grouping together of atoms of substances already known; and it was quite frequently found in normal tubes. Another line, corresponding to an atomic weight of 2·4, was frequently found when mineral substances were bombarded, and the gases driven off analysed by the positive rays. The lines "3" and "3·5" had already been mentioned. Neither of the lines "3" or "3·5" corresponded to elements hitherto recognised, and when found on the positive-ray photographs they were never very strong. This was an indication that they were not present in quantities comparable to the amount of helium contained in certain minerals. Nevertheless they were quite strong enough to measure, and in the plates obtained when zircon was bombarded the line "3" was nearly as strong as the hydrogen line, and the photograph in this case also showed the presence of "3·5".

One of the most important applications of the positive rays was to the accurate measurement of atomic weights. This had already led to some most interesting and surprising results. As explained in an earlier lecture of the course* the deflection experienced by a positive particle was proportional to the square root of its atomic weight, and hence by measuring the positive ray photographs we could compare the atomic weights of the different particles present with, say, that of oxygen. With the small photographs such as had been shown in this course of lectures, the dispersion was insufficient for great accuracy. The degree of dispersion obtained was, however, only a question of the design of the apparatus, and at the outset the speaker had had as his object not the accurate determination of atomic weights, but the analysis of the gases present in a discharge tube. In determining atomic weights by the positive-ray method there was the great advantage that the substance examined need not be pure. If an impurity were present, this impurity simply made its own line on the plate without interfering with the curves due to the other substances present. In chemical methods of determining atomic weights the question of getting rid of impurities was a very serious one, constituting, in short, the great crux to be surmounted before accuracy could be obtained. With the positive-ray method, on the other hand, time spent in purifying the substance to be examined was time wasted.

Moreover, chemical determinations of atomic weights might be vitiated by the presence of isotopes, that was to say of two elements with identical chemical properties but with different atomic weights. We had, in short, reason to believe that the breaking up of radioactive elements gave us four different varieties of lead, each with a different atomic weight, and each inseparable from any of its companions by chemical means, whilst the spectra of the one could not differ from that of another by more than a small fraction of an Angström unit. If, therefore, isotopes existed, which the chemist could not separate from each other, the atomic weight he found might be the average of a mixture and not the true atomic weight of any one of the isotopes present.

In the positive ray method each isotope gave a separate line in the photograph; hence, the method was capable of detecting the existence of isotopes as well as of accurately determining atomic weights. The method accordingly provided the means for solving a number of interesting atomic-weight problems. For example, the atomic weight of nitrogen was anomalous, as it was inconsistent with a rule which applied generally to elements lighter than calcium, berylium being the only other exception. The rule was that if the atomic weight of an element were divided by four, then, with these two exceptions, the remainder was either 0 or 3. In the case of nitrogen with an atomic weight of 14, the remainder was 2, whilst in the case of berylium which had an atomic weight of 9, the remainder was 1. The peculiarity formulated on the above rule constituted very remarkable evidence of something of importance in the structure of the atom. Thinking that the anomaly in the case of nitrogen might be due to that gas being a mixture of isotopes, he had some two years ago studied positive ray photographs of this gas. The conditions were very favourable to accuracy, since lines due to carbon with an atomic weight of 12, and to oxygen with an atomic weight of 16 were recorded on the same plates. The result of the investigation was that nitrogen was not a mixture of isotopes, but had an atomic weight of 14 within an error of less than 1 part in 1,000.

Chlorine was another element, having an anomalous atomic weight. In the case of all other elements the atomic weight, as found by chemists, was approximately a whole number. Chlorine, however, was held to have an atomic weight of 35·46. About a year ago Sir Joseph had accordingly made a number of determinations of the atomic weight of chlorine by the positive-ray method, in order to see whether an isotope were present. The dispersion he used was not sufficient to determine absolute values, within an error of less than about 1 per cent., but he thought that if an isotope existed he should be able to detect lines in the neighbourhood of Cl. not attributable to any known element. He did, indeed, on the positive side of his photographs, find lines corresponding to atomic weights one or two units greater than 35, but he considered that these might be due to hydrides. On the positive side of such photographs, there was, in fact, a whole crowd of lines near the chlorine line. Chlorine, being an electro-negative element, gave a line also on the negative side of these photographs, and on this side there were never many lines. He examined, therefore, a photograph in which the negative line of chlorine was very strong, but he could not find a trace of any other line near it. Hence he concluded that isotopes were absent.

The dispersion he used was not sufficient to

* See ENGINEERING, March 5, page 318.

determine whether the atomic weight of chlorine was 35 or 35·46, as held by the chemists. Recently, however, Mr. Aston, working in the Cavendish laboratory and employing his "focus method" of positive-ray photography, described in a previous lecture (*see* ENGINEERING, page 335 *ante*), had made a series of atomic weight determinations with an accuracy of 1 part in 10,000, with the results recorded below:—

Element.	Recognised Atomic Weights.	Mr. Aston's Determinations for Elements and Isotopes.
H	1.008	1.008
He	3.99	4
C	12.00	12
N	14.01	14
O	16.00	16
Ne	20.20	20, 22, (21)
Cl	35.46	35, 37, (39)
A	39.9	40, 36
Kr	82.9	84, 86, 82, 83, 80, 78
X	130.2	(128, 131, 130, 133, 135)
Hg	200.6	(197, 200, 202, 204)

The figures enclosed in brackets represented provisional conclusions.

In Mr. Aston's photographs, negative lines did not appear, and his results were deduced from the records made solely by positively-charged particles.

It would be seen that Mr. Aston found neon to be a mixture of two elements, with atomic weights of 20 and 22 respectively, with a possible third isotope having an atomic weight of 21. Chlorine, Mr. Aston considered to be a mixture of elements with atomic weights of 35 and 37 respectively, and that there was possibly also a third isotope with an atomic weight of 39. On this view ordinary chlorine was a mixture of two substances, about 30 per cent. of it having an atomic weight of 37 and the remainder an atomic weight of 35. This was very remarkable, and it was difficult to see how the chemist had got such consistent values in his determinations of the atomic weight of chlorine, which agreed within 1 part in 1,000. Chlorine was an exceedingly active element, and as its two components must diffuse with different speeds, it might be expected that, on allowing it to diffuse through a fine copper tube, the compound formed should contain a higher proportion than the normal of one of the two isotopes.

From Mr. Aston's list, it would be seen that argon was a mixture of two elements, one with an atomic weight of 40 and the other of 36. The line due to the latter was very faint. Krypton had no less than six isotopes and Xenon five, but the results in this case were not quite so certain. Mercury, it would be seen, was thought to have four isotopes.

The outstanding point in this series of determinations was that, with the exception of hydrogen, the atomic weight of every element and every isotope was a whole number, that of oxygen being taken as 16. This was a result of first-rate importance, whether in regard to chemistry or in connection with our conceptions as to the structure of the atom. Mr. Aston's determinations were, he thought, but a forerunner of many important results, yet to be obtained by the use of positive rays. These provided the right method of determining atomic weights, and also for detecting the presence of very small amounts of an impurity.

He had, Sir Joseph continued, examined by these methods gases which had been exposed to the action of radium for ten years, being sealed up in the same vessel with a small quantity of radium. The positive ray photographs showed that helium was present in large quantity, as also was hydrogen, whilst the line due to "3" also appeared in the photograph. Similar results were obtained on examining gases which had been exposed for some months to the action of a large quantity of radium. The large amount of hydrogen present was noteworthy, but he could not say whether it was due to the splitting up of certain atoms or had been liberated from the walls of the tube.

The fact that the atomic weights proved to be exact multiples of some unit was, as has been already stated, of fundamental importance, and there was one way of looking at the processes going on in physical phenomena, which would include this as a necessary consequence.

If we studied the effects produced by a moving electron we found that the mass of the electron was due to its charge, and was proportional to the square of this charge. This mass, moreover, was not concentrated in the electron, but was diffused throughout the electric field around the electron, though the concentration was very much greater close in to the electron than elsewhere. The amount of this mass per unit volume at any point P was, in fact, proportional to the square of the electric force at P. Now the electrostatic potential energy at P was also proportional to the square of the force*, and it turned out that this potential energy was equal to the kinetic energy which the mass would possess if it moved with the velocity of light. This was a very suggestive result, for it implied that what was called potential energy might really be the kinetic energy of the mass, which, as stated above, was distributed throughout the whole electric field.

We might generalise this view, and might suppose that all mass, whether of electrons or of atoms, had the same kind of origin, and was really due to mass diffused throughout the electric field which surrounded all atoms and electrons. Mass was, so to speak, an atmosphere around the atom or the electron. Its distribution through space was determined by the distribution of the lines of electric force, and further energy of all sorts, whether kinetic, potential, radiant, chemical or thermal, was of one and the same kind, namely, the kinetic energy of this mass which was supposed to be in motion with the velocity of light. Thus, on this view, when the energy of a system passed from one kind into another; say, from kinetic into potential, there was no transformation of energy, but merely the flow of some of this mass with its intrinsic kinetic energy from one portion of space to another under the direction of the lines of electric force. He had always, Professor Thomson continued, felt that if any kind of reality were to be attached to the term energy, the transformation from one kind to another involved philosophical difficulties. If the matter were regarded solely from the mathematical standpoint kinetic energy being represented by $\frac{m v^2}{2}$ and potential energy as g X, there was no objection to the idea of transformation and the mathematical operations were perfectly valid. If, on the other hand, energy were considered as something real, such a transformation seemed to involve a violation of the principle of continuity and there was a difficulty in forming a physical concept as to what actually took place. He ventured, therefore, to suggest the following method of visualising the processes occurring in physical phenomena. He assumed—(1) That mass was made up of exceedingly small particles of the same kind (very small compared even with an electron), and that these particles moved with the velocity of light; (2) That the force exerted on one of these particles either by the electric field, or by other particles, was at right angles to the direction in which the particle was moving, so that although the path of a particle might be deflected, its energy remained constant. Each of these units had the same mass and the same energy, and the distribution depended upon the number of lines of electric force.

Thirdly, he assumed that the mass of the particles per unit of volume was equal to:

$$\frac{1}{8\pi}\left[\left(f+\frac{\dot{h}v}{c}-\frac{\dot{g}w}{c}\right)^2+\left(g+\frac{\dot{f}w}{c}-\frac{\dot{h}u}{c}\right)^2+\left(h+\frac{\dot{g}u}{c}-\frac{\dot{f}v}{c}\right)^2\right]$$

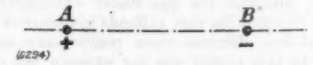
where f, g and h denoted the components of the lines of force parallel to the axes of x, y and z; whilst u, v and w represented the velocities of these lines parallel to the same axes and c was the velocity of light. Starting from this expression, we could, by mathematical processes, obtain the usual equations of the electro-magnetic fields and for the tensions and pressures along and at right angles to the lines of force.

How was it, Professor Thomson continued, if these particles were moving with the velocity of light, that they were able to stay in the electric field? The answer was that though they had the above velocity, they did not move continuously in the same direction but rotated round the lines of electric force, and were anchored by these lines. These lines, however, could only act as anchors if their ends were fixed, that was to say, if they passed from one electrified body to another, as they always did in a steady electric field.

When, however, electrified bodies were moving about, the lines of force moved too, and might be thrown into loops; that was to say, into closed curves without beginning or end. These loops, in the line of force, were then no longer anchored and could no longer hold the particles in place. These, accordingly, took the bit between their teeth and moved away, carrying with them the closed line of electric force. This they did at their full speed, which was the velocity of light. On the hypothesis above advanced, this was the mechanism of radiation. Radiation consisted accordingly of "mass-producing stuff," travelling with the velocity of light and carrying with it lines of electric force. It followed, therefore, that the emission of radiation must be accompanied by a diminution in the mass of the radiating body. The "mass-producing stuff," it would be seen, played a part somewhat analogous to the ether in the older theory, but there were essential differences. The "stuff" was not uniformly distributed throughout the universe, but was concentrated round those places where the electric forces were greatest, that was to say, round the electrons and round the atoms. Again, on this view radiation carried, as it were, its own ether with it, and, where there was no radiation passing, there was no ether.

The "stuff" composed of the particles he had been considering; combined functions which were discharged separately by matter and by ether on the old view. The "stuff," at one and the same time, gave matter its mass, and was the vehicle of radiation. Nevertheless, although it was the source of all mass, and all energy, it was not either the whole of matter (that was to say, electrons and atoms), nor was it the whole of radiation. The lines of electric force were an essential part of both, and formed the skeleton around which the whole structure was built. The ends and beginnings of these lines of force were the places where we localised the electrons and the positive particles which built up the atoms and the molecules, whilst, in radiation, it was the closed line of electric force which the "stuff" carried along with it, which produced that polarity which was essential for the explanation of the properties of light.

It might make things clearer if he considered a particular case, from the point of view of this theory. He would take that of two oppositely-electrified particles A and B, Fig. 1, moving under their own attractions. Let them start from any position; then, on the above hypothesis, the "mass-producing stuff" was distributed round A and B, and it could be shown from the equation given above, that the



(6294)

"stuff" would tend to flow from the weak parts of the electric field to the stronger. Now at A the weak part of the field lay to the left, whilst at B the weak part of the field was to the right. Thus A would gain momentum towards B, and B would gain momentum towards A. The two therefore would tend to move towards each other. Moreover, the "stuff" had come from the outlying parts of the field, where it was regarded as potential energy, and settled round the moving charges appearing there as kinetic energy.

He thought that along these lines we could get a way of visualising a great many physical processes. It was a very great advantage in physical investigations to have some more full-blooded concept of what was happening than was provided by mere mathematical symbols, and this was recognised even by pure mathematicians themselves. For his own part, the treatment of physical phenomena as merely a mathematical problem took away much of its interest.

He might add, in conclusion, that the method above set forth of considering the universe as built up of lines of force, and these small particles rotating round them with the speed of light was consistent with many results of the theory of relativity.

* [Mechanical engineers will note as an analogy that in an elastic rod under tension the potential energy per unit volume is $\frac{P e}{2} = \frac{p^2}{2E}$ where p denotes the stress, e the strain and E Young's modulus.—ED. E.

NOTES.

BASIC SLAGS.

BASIC slag was first put on the soil as fertiliser by the late John Wrightson in 1884. Before the war the annual demand of the United Kingdom for the slag amounted to 263,000 tons; it was 540,000 tons in 1919, and would much exceed 1,000,000 tons this year, Dr. E. J. Russell, F.R.S., remarked in introducing a discussion on "Basic Slags, their Production and Utilisation in Agricultural and other Industries," at the Faraday Society on March 23. As long as the phosphorus was removed from the pig in basic-lined Bessemer converters, there was no dearth of phosphate slag, and a highly phosphoric pig was welcome, since the phosphorus helped to raise the temperature in the converter. But the basic open-hearth has practically superseded the converter; in the hearth the pig is mixed with oxide ore, the oxygen comes not from the air, as in the converter, but from the iron oxide, and from the furnace gases, silicon and phosphorus are removed together, and to get a good phosphate slag, the process is interrupted, and the charge is tapped into a ladle provided with a spout over which the slag flows into a pot ladle. As a rule, however, the simpler process is adopted of letting the whole slag flow over shutes; more slag is then obtained, but it is poorer in phosphate. To treat high phosphoric pig in the basic open-hearth requires a great deal of lime; the slag is then sluggish, and to render it more fluid, Mr. E. H. Saniter added, in 1892, calcium fluoride (or chloride) to the lime. The addition diminishes the solubility of the calcium phosphate which it turns into apatite.* The slag now supplied to the farmer is hence not only less rich in phosphate, but also less soluble. Now there is no question whatever as to the great value of basic slag as a fertiliser; on heavy grass land certainly even the fluor-slag, which may otherwise be somewhat inferior to the older basic slag, gives good results. The figures quoted by Sir Thomas H. Middleton made these points amply clear; he rightly emphasised that the food problem of the farmer was, not to feed 46,000,000 people, who were no longer dependent upon the farmer's efforts, but to feed his cattle and sheep. If the steel-maker must not be expected to work his furnace for producing a superior phosphate slag—the tail must not wag the dog, as Dr. Russell put it—the steel maker does not himself wish to dock the dog's tail, as Mr. Alfred Hutchinson, of Skinningrove, remarked, just as the coke-makers realise that the by-products recovery is in their own interest. The meeting, therefore, after a long, interesting discussion, agreed with the suggestion of Dr. Russell, that a committee of agriculturists and metallurgists should take the basic slag problem up experimentally, and a representative of the Ministry of Agriculture entirely concurred. Enrichment of the slag by the addition of minerals has often been proposed; but Dr. J. E. Stead pointed out that the slag will not take cold additions, and grinding the slag and minerals together would not satisfy the farmer. Together with Messrs. E. Bainbridge and E. W. Jackson, Dr. Stead also contributed a paper on the solubility of basic slags; the calcium silico-phosphates are found to be the most soluble. Mr. G. Scott Robertson, M.Sc., who gave particulars of grass land experiments, also suggested that the slag solubility test (made conventionally by dissolving 5 grammes of the phosphates in diluted citric acid) could profitably be modified. The metallurgical problems of the basic slag formation, explained by Mr. Daniel Sillars, of Messrs. Bolckow, Vaughan and Co., and discussed by Mr. W. S. Jones, Mr. C. H. Ridsdale, Mr. Saniter and others, will require further notice.

WORKMEN'S COMPENSATION FOR ACCIDENT AT A CANTEEN.

The judgments of the Judicial Committee of the House of Lords have usually the great merit not only of deciding the particular case in question, but of settling the law in accordance with broad principles of general application, for the guidance of the lieges in the future. The judgment, a few days ago, in the appeal of Sir W. G. Armstrong, Whitworth and Co., Limited *v.* Redford, will, however, it may be feared, result only in making confusion worse confounded and in rendering it more difficult for those interested in any accident to a worker to know whether it arose out of, and in the course of his or her employment within the meaning of the Workmen's Compensation Act, 1906. The claimant was in the company's employment as a machinist at their works at Openshaw, near Manchester. The workers were not allowed to remain in the works during the dinner-hour (1 p.m. to 2 p.m.), and they had to "clock on" when they returned at 2 p.m. For the convenience of the workers the company had a canteen in the public street, a few yards distant from the principal gate of the works. It was not carried on for profit, but the premises belonged to the company, and it was managed by their women's welfare superintendent. During the day-time the only access to the works from the canteen was by the street. The workers were not in any way obliged to go to the canteen. At 1 p.m. on October 2, 1918, the claimant left the works, walked along the street, and entered the canteen to get her dinner. When coming down the stair from the canteen to the street, shortly before 2 p.m., in order to get back to the works, she slipped and fell and broke her ankle. The arbitrator held that the accident arose out of and in the course of her employment, and he awarded her compensation. This judgment was upheld by the Court of Appeal, and the company appealed to the House of Lords. Probably most lawyers would have expected the appeal to succeed, but by a majority of three to two the House of Lords dismissed it. Lord Finlay and Lord Dunedin held that the course of the claimant's employment ceased when she left the works at 1 p.m., and had not re-commenced when the accident happened. She was her own mistress at the time, and the accident did not arise out of and in the course of her employment. These learned judges were, however, in the minority, and the judgment in favour of the claimant was sustained by the votes of Lord Sumner, Lord Parmoor and Lord Wrenbury. Lord Wrenbury was candid enough to acknowledge that he had given up hope of deciding any case on the words "out of and in the course of" upon grounds satisfactory to himself or convincing to others, but he thought the claimant was in the course of her employment when she was hurrying down the stairs in order to clock on punctually. Lord Parmoor thought that the girl in getting her dinner in the canteen was engaged in a matter ancillary to her employment in a place provided by her employers and where she had a right to be, and the accident was, therefore, incurred in the course of her employment. Lord Sumner, apparently without saying what he would have held, had he been arbitrator, put his judgment on the ground that there was some evidence on which the arbitrator could find that what the girl was doing at the time of the accident was incidental to her employment, and he would therefore not interfere with the arbitrator's finding. Presumably if the accident had happened in a public restaurant the legal result would have been different; but employers who provide canteens for their workers must apparently reckon on the probability of accidents to the workers occurring in the canteens being held to have arisen out of and in the course of their employment even although the canteens are entirely separated from the works.

THE CAKING OF SALTS.

The caking of salts is a frequent source of serious trouble. Salts are ordered ground and dry, are packed or barrelled in that condition, and arrive or are found after storage in the condition of hard rocks, which stick to the barrel and have to be broken up with the aid of a chisel. A good many salts may cause this trouble. Dr. T. Martin Lowry, F.R.S., who read a paper on "The Properties of Powders" before a joint meeting of the Faraday Society and the Society of Chemical Industry on March 1, was confronted with the problem, in the course of a war-time research on ammonium nitrate. Ammonium nitrate, NH_4NO_3, shows pronounced polymorphism, the crystals changing at 32 deg. and at 85 deg. In the vat crystals several feet in length may be obtained. They break up into aggregates of small crystals. Small crystals are in general more soluble than large ones; when moist lumps of small crystals are stacked, the salt is dissolved at the points of contact of the lumps where the pressure is high, and it recrystallises in the open spaces between the lumps, caking the whole mass. In the barrel the salt may turn into a big hard cake frequently showing radial structure, with a lump of egg shape and size at the centre; there may be several eggs. Thorough drying of the salt at about 70 deg. C., Dr. Lowry and Mr. F. C. Hemmings found, prevent the caking and disintegrates the salt, and may advantageously be substituted for grinding. Mechanical disintegration of the warm salt may favour caking. When the water can escape during the grinding operation, caking does not occur. Nitrate crystallised from alcohol cakes very little. Thus moisture is clearly the primary cause of the caking, but the conditions are complex. Sodium nitrate also cakes, but not when commercially dried under conditions which are bad for ammonium nitrate. Potassium nitrate hardly cakes, and the tendency to caking of these three nitrates is in the inverse order of their solubility in water, which is evidently an important factor. Common salt (when impure with magnesium chloride), soda ash, potassium chlorate and perchlorate, and citric and tartaric acids, likewise cake; the compounds should be dried during or after grinding and packed dry. The salts so far mentioned do not contain any water of crystallisation. Hydrated salts, borax, sodium phosphate, alum, Rochelle salt (potassium-sodium tartrate), are very liable to caking and difficult to dry, because the drying may lead to decomposition. Mechanical working favours the release of included moisture, but may also have the effect which cold working has on metals when they turn amorphous; the caking in these instances seems chiefly to be due to recrystallisation. In the case of sodium bisulphite the changes are more complex, because water is absorbed, while sulphur dioxide escapes. Dr. Lowry's observations on copper sulphate are interesting. This salt (blue vitriol) crystallises with five molecules of water. The water is lost by heating, and with the loss of the last molecule of water the sulphate changes into a white powder, which absorbs water and turns blue again. Dr. Lowry observed that the reabsorption of water is accompanied both by caking and swelling, but that during the absorption of the last molecule a strong contraction takes place. A little more moisture is in fact absorbed than corresponds to the five molecules, but the excess is lost again. Caking and shrinkage of volume in this case seem to be due to the simultaneous presence of the trihydrate and of water saturated with the pentahydrate, in which the trihydrate dissolves and crystallises out again in the ordinary form. The pelleting of these various salts by compression was mentioned during the discussion. As regards the pressures required, Professor A. W. Porter, who was in the chair, remarked that it was necessary to distinguish whether the pressure acted on both the solid and the liquid, or whether the liquid could escape. In the regelation of ice a pressure of 140 atmospheres would lower the melting point by 1 deg. in the former case, and by 10 deg. or 11 deg. in the latter.

THE WORK OF THE LATE LORD RAYLEIGH.

The homage which Sir J. J. Thomson paid to "the Scientific Work of the late Lord Rayleigh" at the Royal Institution, in last Friday's discourse, came from one of Rayleigh's first pupils in the Cavendish Laboratory, a pupil who later succeeded his teacher in the professorial chair, both at Cambridge and in the Royal Institution, as well as in the presidency of the Royal Society. As the artist could only be judged by the artist, Sir Joseph remarked, so the unrivalled technique, the dynamic insight into the nature of a problem, and the breadth, refinement and difficulties of the work of the "Physicists' physicist," whose favourite mode of expression was by mathematical symbol, could fully be appreciated only by the expert. But we had 400 memorial tablets in Rayleigh's papers, written

* The mineral apatite is not merely a calcium phosphate; it always contains as a normal constituent (not as an admixture) either fluorine (fluorapatite) or chlorine (chlorapatite).

from 1865 till his end,* and from these Sir Joseph selected some matters of daily experience. Speaking of Rayleigh's early work on the Theory of Resonance, he said that it was easy to calculate the pitch of a resonator when one neglected the hole through which the sound was excited and emitted, but a hard problem when the hole was taken into consideration; Rayleigh applied his principle of dynamic similarity in these researches. As regards our power of distinguishing sound direction, our head would throw a shadow, so that sound waves coming from the left would appear more intense in the left ear than in the right; that, however, would hold only for sounds of high pitch, when the wave-length was small compared to the distance between our ears. Rayleigh showed that the ear could detect differences in pitch and in intensity, and further differences in phase, by experimenting with telephones applied to both ears in which he varied the phase. But neither of these explanations accounted for our ability of distinguishing between sounds from front and back—where the shape of the ear might help—and we could not say whether insects like ants, in whose cases the distance between the ears vanished, could possess any sense of sound direction. The sensitiveness of our ear was marvellous; it could respond to pressure changes of 1/100,000,000th of an atmosphere, differences which no instrument could measure, and Rayleigh also found that the sensitiveness of our eye was of the same order. In the whispering gallery of the dome of St. Paul's, the sound waves, Rayleigh concluded, clung to the wall as if they were hemmed between two concentric domes. To make the sound issuing from a fog horn spread sideways horizontally he demonstrated that the oblong aperture should be a vertical, not a horizontal slit. Passing to capillarity and fluid motion, Sir Joseph stated that Rayleigh proved aeroplane flight to be possible because the lift was proportional to $\sin\theta$ (θ being the angle between the plane and the direction of motion), and not to $\sin^2\theta$, as had been assumed. The resistance to the motion would depend upon the shape, size, speed, &c., and thus upon $\rho v^2 F$, F itself being a function of $l v/\nu$, where ρ and ν were the density and viscosity of the air and v and l the speed and length of the plane. In practice F was taken as constant; though very large F was not constant, however, and that might explain why deductions from model experiments and the principle of dynamic similarity were not in complete agreement with machine performances. As regards the soaring of birds, Rayleigh suggested in 1892 that a bird dropping from high altitude into a lower region in which the wind velocity was smaller would gain energy to rise to a greater height, and that was now accepted. Rayleigh's electric and magnetic work was largely done in the Cavendish Laboratory, and he gave the Nobel prize award for the extension of the laboratory. Rayleigh's advice to experimenters was: "Do not place too much reliance on the instrument makers," the exhibits exemplified what he himself could accomplish with wood, glass and sealing wax. In his concluding words, Sir Joseph emphasised one great feature of Rayleigh's character: His judgment was never clouded by prejudice.

THE FARADAY SOCIETY AND THE NITROGEN PRODUCTS COMMITTEE.—Before opening the discussion on "Basic Slags" at the meeting of the Faraday Society on the 23rd ult., Sir Robert Hadfield, Bart., F.R.S., President of the Society, said a few words on the work of the Faraday done during the war in connection with the nitrogen problem. It should not be forgotten, Sir Robert remarked, that the Faraday Society had taken the initiative in originating experimental research on the fixation of nitrogen; among the chief members of the sub-committee of the society, out of which the large influential Nitrogen Products Committee had grown, had been Dr. J. A. Harker, Professor K. A. Huntington, Mr. W. R. Cooper, Mr. F. S. Spiers, the secretary of the society, and Professor Donnan, who was able to place part of the chemical laboratories of University College at the committee's disposal. Important reports had been issued, the processes developed had been adopted both here and in the United States, and the value of the work of the Faraday Society had fully been acknowledged by the Munition Inventions Department at the time, and again after the war.

* On June 30, 1919; see ENGINEERING, July 4, 1919, pages 19 to 21, and the correction of a few errata on page 48 of July 11.

LITERATURE.

I. *The Analysis of Minerals and Ores of the Rarer Elements.* By W. R. SCHOELLER, Ph.D., and A. R. POWELL. London: Charles Griffin and Co. [Price 16s. net.]

II. *The Metals of the Rare Earths.* By JAMES FREDERICK SPENCER, D.Sc., F.I.C., Lecturer in Physical and Inorganic Chemistry, Bedford College, University of London. London: Longmans, Green and Co. [Price 12s. 6d. net.]

I. WHILE it is customary to speak of the rare earths, the term "rarer metals" has scarcely any recognised meaning. One of the properties which make gold precious is its relative rarity. Yet gold is very widely disseminated, and in that sense several of the metals with which Messrs. Schoeller and Powell deal cannot much more be considered rare. Of the three alkali metals, which they discuss, lithium occurs in many rocks, in nearly all water and in plant ashes, and when Sir William Ramsay, in his supposed transmutations, spoke of lithium as a rare element, he was justly criticised because the traces of lithium with which he was concerned are far more difficult to avoid than to find. The other two alkali metals, rubidium and caesium, are certainly rarer, because only found in minute quantities, and caesium in particular is hardly obtainable; yet the general occurrence is that of lithium, and there are a few caesium minerals. But minerals of gallium and indium are unknown, and they are as rare almost as radium, which is practically found only in uranium ores, themselves scarce. Of the rare earths we shall speak presently. We are not certain that the reader would look, in the octavo volume of 239 pages before us, for titanium, vanadium, molybdenum, tantalum and the platinum metals; he would scarcely expect to find selenium among the rarer metals, because it is neither rare nor a metal; but the next member of the sulphur-selenium group, tellurium, is quite metallic and undisputably rare.

Observing that writers and teachers still adhere to the arbitrary separation into common and rare elements, Messrs. Schoeller and Powell wish to supplement the very scanty information which text books give as to the analysis of ores and minerals of the rare elements. That is a praiseworthy object. We have hardly ever seen a book in which so much useful information is condensed into so small a space; there are no unnecessary words, and the authors have gone as far in the condensation as is compatible with lucidity and fluidity of language. Their analytical details are amply stocked with the most recent literature and several novel analytical methods are proposed, general as well as special, with regard to the rare earths, *e.g.* After an introduction on analytical practice, crushing of material, choice of crucible to avoid corrosion and contamination, spectroscopy, &c., follow general analytical tables, and the elements are discussed separately, grouped according to the periodic law. In each case we find general remarks, a summary of minerals, properties and compounds, notes on quantitative separation, detection and determination in ores, and an outline of complete analysis. The book is compiled for analytical chemists, metallurgists and advanced students. We should like to have more information about melting-points and general properties and references to the sources from which the constants are taken, which in several cases differ from those given in recent text books and may still be uncertain. But it would be unreasonable to make that a complaint; the authors have quite sufficient to do with their analyses.

II. THE term "rare earths" has come into use as a group name for an apparently large number of oxides of earthy character which, very similar in properties and exceedingly difficult to isolate, are always associated in certain minerals of sparse occurrence. Their study is by no means recent. At first those minerals were only found in Scandinavia, and most of their early investigators, Gadolin (1794), Ekeberg, Berzelius and later Mosander, Cleve and others were Swedes. Already, by 1800, however, we find Klaproth and Vanquelin among these workers, and in the latter half of the past century some of the most distinguished chemists of all nationalities were engaged in the separation of the rare earths. Many a new element discovered broke down under further tests or proved only to be a more pure preparation of some known element. Thus the new elements donarium, damarium, lucium, mosandrium, didymium, victorium, kosmium and daemonium, have long since been deprived any right of existence, and the still long list is at present confined to cerium, lanthanium, neodymium, praseodymium, samarium, yttrium, europium, gadolinium, lutecium, neoytterbium [erbium, terbium, dysprosium, holmium, thulium, and celtium]. But the elementary character of the metals we have put in brackets has often been questioned, and Brauner and others have indeed doubted cerium. Dr. Spencer himself feels doubtful as to cerium on the strength of some unpublished research of his own. On the other hand, he includes scandium in the rare elements, which Dr. Schoeller classes with gallium, indium and thallium. Thorium is generally reckoned among the rare earths, because they accompany thorium in its minerals, though it chemically stands apart in some respects. Zirconia resembles the rare earths, but does not chemically belong to them.

The great technical problem of forty years ago, to find a material which would stand the heat of the Bunsen flame for a reasonable period and yield an inexpensive light of high intensity, had been solved before the discovery of large deposits of monazite sands and other rare earths in Brazil and Carolina, and subsequently in Travaniore and elsewhere, stultifying the name "rare earths" to a certain extent, made the huge development of the incandescence gas burner possible. The solution was pre-eminently due to the systematic researches of the late Auer von Welsbach, who succeeded in splitting up didymium into neo- and praseodymium and whose name has similarly been split by fame: what is known as the Welsbach mantle over here is called the Auer stocking on the Continent. Dr. Spencer deals briefly with the mantle industry and generally with technical features in his last chapter; he also explains the treatment of the monazite, which is still kept secret to a large extent. His object is to give, so far as possible, all the information about the rare earths and their compounds that text books contain about the common elements, and he reviews in particular the methods employed for their separation. How thoroughly he has studied the literature on the subject is proved by the 1,029 literature references, which are quoted by numbers and cover in their list 20 of the 279 pages of the octavo volume; these references are brought up to July, 1918. Dr. Spencer divides the rare earths into two groups, the cerium group and the yttrium group; Messrs. Schoeller and Powell distinguish a third, intermediate terbium group. Why Dr. Spencer has given his book the title "The Metals of the Rare Earths," we cannot say. Metallic scandium has never been isolated at all; in many cases Dr. Spencer makes no statement as to the metals, most of which are certainly not yet known in a state of conventional chemical purity; and technically only the pyrophoric cerium metal or metals have any importance as such.

Owing to the exceedingly clanny nature of the rare earths the ordinary methods of separation fail; quantitative separations, in fact, are still unknown practically. The chief methods used are based: (1) On the solubility of their salts and double salts in various solvents, and on their fractional crystallisation; (2) on their basicity or fractional precipitation by various reagents; (3) on processes of oxidation; that is to say, the salts are converted into oxides by heat or other agencies and then taken up in acids; (4) on physical processes, adsorption by charcoal, distillation, and electrolysis; the electrolysis of solutions yields the oxide, the electrolysis of the fused anhydrous chloride in the case of cerium the "Mischmetall." All these separations are fractionations and have to be repeated many times to isolate any particular element or compound, and the fractionations are controlled by determinations of the equivalent weights (a laborious method, of course), by spectroscopic observations (flame, arc, spark, absorption, and phosphorescence spectra), and by determinations of the magnetic susceptibility. The indexing—there is a special index of the bibliography—deserves commendation.

Enough of the rare-earths residues have accumulated to facilitate their further study. Scientifically the rare earths are very interesting. Their atomic weights all lie between about 140 and 180; that is one of the reasons why scandium (44·1), yttrium (89·3) and thorium (232·15) stand apart. The rare earths used to be put into the third and fourth groups of the periodic table: they certainly do not fit in there, nor into any other group. If ceria should really prove to be complex, certain radiation problems of the incandescence mantle will have to be revised. Technically much more use could probably be made of the rare earths, as Dr. Spencer points out in his last chapter. Some of the metals are pyrophoric*; they are also added to flashlight powders; a small percentage of cerium (0·2) is said to improve aluminium; the earths make powerful catalysts; they have been utilised in the textile, photographic and keramic industries; they have medicinal properties. All those matters should be investigated further. The scientific problems, at any rate, should, in our opinion, be taken up by some institution; the tasks are too big for individual research.

BOOKS RECEIVED.

Profit-Sharing. A General Study of the System as in Actual Operation. By ALBERT TROMBERT. London: P. S. King and Son, Limited, Orchard House, Westminster, S.W. [Price 2*s.* 6*d.* net.]

University of Illinois, Engineering Experimental Station. Bulletin No. 112. *Report of Progress in Warm-Air Furnace Research.* By A. C. WILLARD. Urbana: Published by the University of Illinois; London: Chapman and Hall, Limited. [Price 35 cents.]

Mathematics for Engineers. Part II. By W. N. ROSE, B.Sc.Eng.(Lond.). London: Chapman and Hall, Limited, 11, Henrietta-street, W.C. 2. [Price 13*s.* 6*d.* net.]

General Conditions of Electrical and other Engineering Contracts. By WILLIAM SMITH KENNEDY. With an introduction by Sir ALEX. B. W. KENNEDY, LL.D., F.R.S. London: Sweet and Maxwell, Limited.

The Journal of the Institute of Metals, Vol. XXII. Edited by G. SHAW SCOTT, M.Sc., Secretary. London: Published by the Institute, 36, Victoria-street, Westminster, S.W. 1. [Price 31*s.* 6*d.* net.]

Education and Training for the Electrical and Allied Engineering Industries. Being a Report of the Education Committee of the British Electrical and Allied Manufacturers' Association. London: Edward Arnold. [Price 3*s.* 6*d.* net.]

Peat Industry Reference Book. By FREDERICK T. GISSING. London: Charles Griffin and Co., Limited. [Price 7*s.* 6*d.* net.]

Ships' Boats—their Qualities, Construction, Equipment and Launching Appliances. By ERNEST W. BLOCKSIDGE, M.Inst.N.A. London: Longmans, Green and Co. [Price 25*s.* net.]

The Lathe, Bench Work and Work at the Forge. By HENRY D. BURGHARDT. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 12*s.* net.]

Oil Engines; Details and Operation. By LACEY H. MORRISON. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 30*s.* net.]

Telephonic Communication, Theoretical and Applied. By J. G. HILL. London: Longmans, Green and Co. [Price 21*s.* net.]

Chemists' Manual of Non-Ferrous Alloys. By JAMES R. DOWNIE, F.C.S. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 10*s.* net.]

Structural Steel Work. Relating Chiefly to the Construction of Steel-Framed Buildings. By ERNEST G. BECK, Assoc.M.Inst.C.E. London: Longmans, Green and Co. [Price 21*s.* net.]

The History of Trade Unionism. By SIDNEY and BEATRICE WEBB. Revised edition, extended to 1920, London: Longmans, Green and Co. [Price 21*s.* net.]

Notes on Coal Analysis. By F. S. SINNATT, M.B.E. M.Sc. Manchester: The Lancashire and Cheshire Coal Research Association. [Price 2*s.*]

PIG-IRON AND STEEL PRODUCTION.—The production of pig-iron in the United Kingdom last February was 645,000 tons, compared with 665,000 tons in January. Making allowance for the shorter month, the rate in February was rather higher than in January, 22,300 tons as against 21,500 tons. The production of steel ingots and castings was 798,000 tons, as against 754,000 tons in January. The American production of steel ingots in February, by 30 companies, who made about 84·03 per cent. of the total steel ingot production of 1918, amounted to 2,152,106 gross tons of open-hearth, 700,151 gross tons of Bessemer and 12,867 gross tons of all other steel, a total of 2,865,124 gross tons, as compared with a total of 2,704,683 gross tons in February, 1919. The total production of steel ingots in the United States in February, 1920, may therefore be taken as approximately 3,410,000 gross tons.

* Cf. our Note on Cerium Iron Alloys, ENGINEERING, August 17, 1917, page 170.

INDUSTRIAL NOTES.

THE Ministry of Labour issued last week a statement to the effect that the Government had under consideration the urgent need for an inquiry into the question of increased production in industry, and it has been decided to set up a committee to consist of an independent chairman and a permanent nucleus composed of two employers, two labour representatives and two Government representatives, together with additional representatives appointed, two by the employers and two by the workpeople, to represent any particular trade which may be under consideration by the committee. These trade representatives will leave the committee when the inquiry has been completed so far as regards their particular trade. The committee consists of Sir Stephenson Kent, K.C.B.; Mr. I. Haig Mitchell; Lieutenant-Colonel D. Paul, C.M.G.; Mr. A. A. Purcell; Sir Thomas Robinson, M.P.; Sir Allan M. Smith, K.B.E., M.P.; Mr. G. H. Stuart-Bunning, J.P., O.B.E. The secretary is Mr. W. H. Reynolds, M.B.E., Ministry of Labour, to whom any communication with regard to the committee should be addressed, Montagu House, Whitehall, S.W. 1. The terms of reference of the committee are "To consider and advise as to the best means of securing the greatest possible production consistent with the permanent well-being of industry and of the employers and the workpeople engaged therein." The building trade is the first trade that will receive the consideration of the committee.

Speaking at Northampton last Saturday, and referring to the forthcoming budget, Mr. J. H. Thomas, M.P., said it was no secret that in advance the Government were going to show a surplus for the year. If any business concern were to deal with their balance sheet in the same way they would be both insolvent and bankrupt. There was a known deficit of over 400,000,000*l.* more than three months ago, and the balance was to be made up by bringing into this year's revenue account the sale of surplus war material. This for all legitimate purposes was capital expenditure. Criticising Mr. McCurdy and the Government in relation to prices and profiteering, he said that if they relied upon more investigation to reduce prices they would be starved before it was completed. There was a great boom in capital issues, and there would have to be a larger return on this inflated capital, and the working classes would have to pay for it. While the great trades unions could use their industrial powers to obtain advances in wages, it was very different with the soldiers' and sailors' widows, old-age pensioners, and people with fixed incomes, without any trade union behind them. They were the people who were being squeezed by high prices, and mere advances of wages were not the real remedy.

According to *Modern Transport* a scheme has been drawn up by the Ministry of Transport for the future administration of the railways, and is now being considered by the Cabinet. It provides for the distribution of the railways of England and Wales into four districts, the division being largely based upon the working agreements which were in operation between groups of railway companies prior to the war. The grouping would be as follows: (1) North-Eastern and Central System—Great Central, Great Eastern, Great Northern and North-Eastern Railways; (2) North-Western and Midland System—London and North-Western, Midland, Lancashire and Yorkshire, and North Staffordshire Railways; (3) South-Western and South Coast System—London and South-Western, London Brighton and South Coast, and South-Eastern and Chatham Railways; (4) Western and Wales System—Great Western, Cambrian, and South Wales Railways. The Scottish railways together would constitute a separate district, and the electric railways of London would form another district.

With reference to the question of the miners' wages, the following statement was issued last week by the Coal Association: "The coalowners' view is that, in offering a 20 per cent. increase of wages on earnings apart from the war wage and the Sankey wage (see page 422 *ante*), the Coal Controller has acted generously towards the miners. He appears to have offered so to increase the wages of those working in the mining industry as to leave no possible doubt of their favourable position relatively to the work-people in other industries. It is notorious that in the past as wages have increased the output per man has decreased, and there is doubtless a hope in the Controller's mind that in a national emergency such as the present, when coal and all other goods are so urgently needed for export in order to re-establish our national finances and credit, such generous treatment of the miners would not have this usual and disappointing effect. As to the cost to the nation, *i.e.*, the consumer, since house coal has for some time past been produced at a loss, there appears to be no other choice than that between a rise in the price of coal all round or another subsidy, either of which comes to exactly the same thing—in the end the consumer pays." A conference took place on Thursday, March 25, between the Prime Minister and the Miners' Executive, when the Government offered to increase the boys' rates by 9*d.* per shift, instead of 6*d.*, the offer of an increase of 1*s.* 6*d.* to men remaining the same. This amended offer was based upon the acceptance of the percentage principle of advance in wages, that is to say, that the Government's offer of an advance of 20 per cent. all round remained in force, given with a guarantee that no man should have less than the equivalent of 1*s.* 6*d.* per day flat rate increase and no boy have less than the equivalent of 9*d.* per day flat-rate increase. The miners' delegates met last Saturday morning, and after the meeting, Mr. Hodges made the following statement: "The chairman and myself reported to the conference the result of the interview we had with the Government. In pursuance of the powers vested in us by the Executive Committee, we proposed that the flat rate amounts should be varied in the following order: 3*s.* per day for all working members of the Federation if 18 years and upwards; 2*s.* per day between 16 and 18 years of age; 1*s.* per day up to 16 years of age. A percentage basis of 22½ per cent. advance to be paid for all workers with the guaranteed minimum. We further reported that these proposals did not appear acceptable to the Government, who desired, however, an opportunity of examining our figures and their own, that they might be able to make a definite proposal to the Executive Committee on Monday morning at 11 o'clock. We will meet the Prime Minister at 10, Downing-street, at that hour." Mr. Hodges added that the Federation still claimed that any advance granted should apply as from March 1, whilst the Government's previous offer was that the advance should start as from April 1. At the said meeting of Monday last, the Government made the following final offer to the Federation. An advance of 20 per cent. on gross earnings, excluding the war wage and the Sankey wage, with a guaranteed minimum advance of 2*s.* for men, 1*s.* for youths between 16 and 18 and 9*d.* for boys under 16. The Federation are preparing a ballot of the miners on this final offer; the ballot papers are to be returned to the offices of the Federation on or before April 14, and the result of the ballot will be announced to a delegate conference to be held in London on the following day.

A number of prominent shipbuilders on the North-East Coast have issued a manifesto stating that the failure of the railways to handle the country's traffic efficiently is so seriously interfering with the manufacturing operations as to call for public notice and the institution of immediate remedial measures in the national interest. The prevailing conditions, congestion at the docks, delays in transit and increased costs, are making themselves adversely felt in every direction, lessening production, causing unemployment, inflicting losses on the community and increasing the cost of living. The manifesto goes on to say that the steel makers of the country have successfully introduced the system of three shifts of 8 hours for each working day of 24 hours, and the country's interests demand that the railways shall be worked in like manner to make the utmost use of the rolling-stock available and thus to relieve the present situation, which is preventing the full play of trade and retarding the nation's economic recovery. The shipbuilders referred to submit that the need for utilising the country's existing railway plant to the fullest capacity is imperative, and that steps should be taken to give effect to this without delay. If there is a shortage of men, it should be noted that there are still numbers of unemployed who can be trained for railway work, including many officers and soldiers for whom work has not been found. In the meantime and until additional railway shifts have been organised, the present railwaymen should be asked and should agree to work overtime. It is reported that manufacturers in other parts of the kingdom are giving their support to the manifesto of the North-East Coast shipbuilders.

ROYAL AERONAUTICAL SOCIETY.—An application having been received from the British Imperial Antarctic Expedition for assistance in connection with the proposal to use aeroplanes for survey work with the expedition, the council of the Royal Aeronautical Society have offered to assist by advising on the types of aircraft most likely to prove suitable and also on technical equipment and details generally. It is proposed to carry out preliminary experiments in the Arctic regions over a period of twelve months before sending any machines to the Antarctic. In response to an invitation from the Air Ministry, Mr. Alec. Ogilvie, F.R.Ae.S., has been nominated to represent the society on the new Aeronautical Research Committee, which is taking the place of the Advisory Committee on Aeronautics. Dr. R. Mullineux Walmsley has been similarly nominated to the Advisory Committee on Aeronautical Education.

THE EFFECT OF CIRCULAR HOLES ON THE DISTRIBUTION OF STRESS IN TENSION MEMBERS.

TO THE EDITOR OF ENGINEERING.

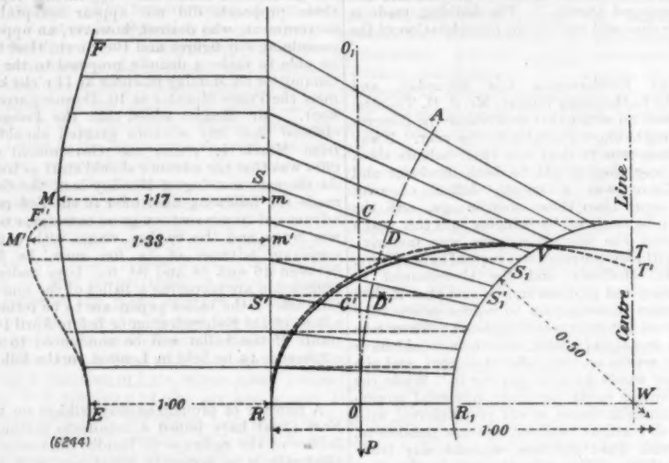
SIR,—In his very interesting paper on "The Effect of Circular Holes on the Stress Distribution of Tension Members," Professor E. G. Coker mentions the fact that the value of $\frac{P - Q}{P}$ reaches a *minimum* at its intersection with the minimum section (and not a *maximum* as one might expect); in other words the curve showing the variation of stress along the boundary, parallel to the pull, has a minimum ordinate at the minimum section and a maximum higher up.

As Professor Coker writes that "this somewhat unexpected result is not likely to be predicted from general consideration," it might interest your readers to see how simply this result may be predicted by applying the elementary laws of stress distribution due to combined bending and tension.

In the enclosed sketch we have taken the same example as the one dealt with by Professor Coker in Fig. 13A, page 262 (width of plate 1·00; diameter of hole 0·50).

The stresses acting in the minimum section R R_1 have a resultant P, applied at a certain point O, which, in this elementary theory, we will assume to be equidistant from R and R_1.

Let us now consider the part of the plate limited, on one side, by the edge R S of the tension member and, on the other side, by the circular hole R_1 S_1 V, and let us look upon it as a curved beam, fixed somewhere at its upper part and free at the minimum section R R_1, where force P acts upon it.



The centre line of this beam is a curve O A, drawn in such a manner that a section S S_1, perpendicular to it at D, cuts the two boundaries of the part plate under consideration, in two points S and S_1, equidistant from D.

Having drawn a series of sections similar to S S_1, it is easy to find the stress produced in one of them, under the action of the force P applied at point C: P gives a shearing force and a normal pull acting with an eccentricity equal to C D. The stress at S can at once be calculated and plotted as ordinate of a curve E M F. In this way it is found that the maximum stress occurs at a distance from the minimum section equal to about the radius of the hole; the maximum stress is equal to 1·17 times the stress at the minimum section R R_1.

The stress round the hole can be found in the same way (at S_1, for example) and has been plotted as radial ordinate of the full-line curve R V T, showing, as the more exact theory of Professor Coker, that the upper part of the hole is under compression.

We might have looked upon the beam R S S_1 R_1 as being built up of *horizontal* sections S' S'_1 instead of inclined sections as S S_1. In this case the equation of the curve of stresses along the edge R S can easily be found (it is too elementary to be done here in detail) and the dotted curve E M' F' is obtained, giving a maximum ordinate equal to 1·33 times the stress in the minimum section.

The dotted curve R V T' represents in this case the stresses round the hole.

In short, it is very easy to predict the stress distribution found by Professor Coker as far as the *general shape* of the curves is concerned.

The difference between maximum and minimum stresses along the edge R S is, however, greater in reality than shown by the above simple theory. This simple theory, moreover, does not explain why the stress distribution in the minimum section R R_1 is not uniform.

Also, I do not pretend to oppose this simple theory to Professor Coker's highly interesting experimental and theoretical work. I only wish to show how some of the most unexpected results are in accordance with simple theory.

Yours faithfully,

G. R. MAGNEL, I.C.C.,
Répétiteur à l'Université de Gand.

Gand, le 29 février, 1920.

"AEROPLANE STRUCTURES."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the review which appeared in ENGINEERING of March 5, page 299, and Mr. Pippard's letter published on page 421 of your issue of March 26, the author and your reviewer are a little at cross purposes. The remarks on the generality of problems on struts were only meant to apply to worked-out design-room methods for obtaining numerical solutions, from which reasonable point of view they are strictly correct.

If it is desired to compare merely formal statements, Perry's is the most general for a single strut, as he indicates the possibility of numerical solution for any end loads, end moments and distribution of load along the strut.

Morley, if memory serves, is somewhat less general, both as to end moments and distribution of loading, but his worked-out problem is more general as already stated.

Manderla is completely general as to end moments and end forces, but only considers constant shear force along the strut, so that the function of x only, in his differential equation, is linear.

He works out the problem completely, not only for a single strut, but also for a complete framework, giving a design-room method of computing numerical values, by tabulating the functions (given here in Berry's notation) $\alpha/(1 - \cot \alpha) \pm \cot \alpha$.

Thus, taking the formal, as well as the design-room solutions, it is still correct to say, though on somewhat different considerations, that Manderla solved a much wider problem than either Perry or Morley.

While commenting on the review, it might be as well to add C. E. Grimm's "Secondary Stresses" (Wiley and Sons, New York) to the bibliography of the method of internal work.

I am, &c.,

"YOUR REVIEWER."

London, March 26, 1920.

THE DEVELOPMENT OF METAL CONSTRUCTION IN AIRCRAFT.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Sutton Pippard has pointed out an important correction, which should be applied to the curves given by Major Nicholson in his paper reported in ENGINEERING of March 19.

In the original paper Major Nicholson does not refer to the fact that all the experiments on spars were done in the Civil Engineering Department of the University of Birmingham under my supervision, and that he received nearly all his data on spars as liaison officer between my laboratory and the R.A.F. As this is known to many I take the opportunity of first thanking Mr. Pippard for the compliment he pays to the experimenters and designers, and further saying that I fully agree with Mr. Pippard that the Perry formula for uniformly distributed loads should not be used to compare experimental with theoretical results, in which concentrated loads at two points, instead of uniformly distributed loads, were used. There is no necessity to do so, as it is almost as easy to deduce the exact formula for the two concentrated loads as for the uniformly distributed loads. In the report, which, together with two of my assistants, Mr. Coupland and Mr. Naylor, I have prepared on this experimental work, we have included theoretical analysis of the two point loaded struts, and have shown that for certain points of loading a curve can be plotted having bending stress due to lateral and direct loads as ordinates as distinct from resultant stress, and deflections as abscissæ, which has certain very interesting properties and from which, since it is a practically straight line, it is possible to discover the point at which the elastic limit of the material was reached. The curves plotted by Major Nicholson, from the results of our tests, and also the theoretical curves erroneously used by him and the curve suggested by Mr. Pippard, are in no part of them straight, and the elastic limit cannot, therefore, be accurately determined.

I think it is only fair in conclusion to say that, unintentionally I am sure, Major Nicholson has probably done an injustice to Major Wylie, to Mr. E. Coupland, M.Sc., and others of my assistants in that he has not acknowledged the source of the experimental data on spars which he gives in his paper.

Yours faithfully,

T. C. LEA.

The University, Edgbaston, Birmingham,
March 30, 1920.

"THE CAMMELLAIRD-FULLAGAR ENGINE."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the correspondence on the above subject, Mr. Everett's last letter indicates that he is not well versed in oil-engine matters. Supercharging of opposed piston engines has been in use for about eight years and has been widely noted in the engineering press on many occasions. In ENGINEERING alone he will find four or more explanations of the system during that period, and it is difficult to imagine how any oil-engine expert could have missed them.

Providing the scavenging pumps are made big enough it is only necessary to throttle the engine exhaust, say at the silencer, when any desired degree of supercharge can be obtained. With slight modifications this method can be put on any engine two or four cycle, but, as Mr. Shannon says, any form of supercharging is undesirable and wasteful, especially when the engine naturally does not require it.

Although I am not familiar with the details of the above named engine it would be a simple matter to cool the lower pistons with water by any of the well-known methods used on other engines, and Mr. Everett is only trying to manufacture a case by pretending not to see this. Whilst not agreeing with all that has been written, I certainly think that Mr. Everett is building up his case on *argumentum ad ignorantiam*.

Yours truly,

L. A. LEITCH.

3, Caledonia Buildings, Clydebank.

UNIVERSITY COLLEGE STUDENTS.

TO THE EDITOR OF ENGINEERING.

SIR,—We trust you will give us the hospitality of your columns to call the attention of former students of University College and University College Hospital, London, to the Memorial we are endeavouring to raise to college and hospital men who fell in the war. Owing to the many changes that have taken place during and since the war, our address list is not complete. It will be of great assistance to us if all members of the college who have not already received our appeal will send postcards with their names and addresses and dates of students years to the hon. secretary. We shall then be very glad to send them full particulars of our War Memorial scheme. We hope we may rely on the support of all students past and present.

Yours faithfully,

GREGORY FOSTER, Chairman.
G. BLACKER, Vice-Chairman.
LAWRENCE SOLOMON, Hon. Secretary.

University College, London, March 25, 1920.

THE RELATION OF EMPLOYER AND EMPLOYEE.

TO THE EDITOR OF ENGINEERING.

SIR,—In a paper read by Sir Alfred Yarrow before the Institution of Naval Architects he insists upon the necessity of employers and their workpeople coming into personal intercourse with one another as the best and only means of securing harmony.

Might I suggest that a copy of Sir Alfred's paper be sent to every shipbuilder and to all their men throughout the country.

Yours faithfully,

"SHOP STEWARD."

March 27, 1920.

ELECTRIC CONDUCTIVITY OF SOLID SALT MIXTURES.—In 1897, Fritsch observed that the electric conductivity of powdered solid salts, each itself generally a poor conductivity was increased many times by mixing the salts. His figures were not tested till 1912, when M. Le Blanc found that the increases in conductivity were very much smaller than stated. Renewed experiments made by R. Kretzer on Le Blanc's suggestion (Zeitschrift für Elektrochemie, February 1, 1920) prove that the mere mixing has very little influence on the conductivity of powders, and that experimental difficulties and the uncertainties of drying the salts, compressing the powders, and assuring good electric contact between the powder and the electrodes should make us very cautious as to the interpretation of the results. When lead chloride or bromide was mixed with potassium or sodium chloride, its conductivity increased or decreased very slightly. When the lead chloride was alone dried at 300 deg. C., its conductivity rose 10 times and more; but when it was mixed with the alkali chloride before being compressed and preheated, the conductivity rose several hundred times. In the case of the pure lead chloride the preheating in a vacuum, in air, nitrogen and chlorine sometimes produced distinct chemical changes, without affecting the resistance much. The improved conductivity might partly be due to incipient fusion of the small crystals or to a kind of coherer effect; chemical reactions and the degree of drying and compression and contact with electrodes (amalgamated copper) will certainly be factors to be reckoned with.

NOTES ON OUR ECONOMIC POSITION AS A SHIPBUILDING COUNTRY.*

By Sir ALFRED YARROW, Bart., Vice-President.

MANY of us are so absorbed by the technical side of our profession that we are apt to forget to study the fundamental principles upon which the economic side is founded. Every one will admit the importance of sound finance in a shipbuilding business, but it does not get that public examination and discussion which we give to even minor technical details. I do not recollect, for instance, any paper on the subject in our Transactions. If the financial position of the country is bad, or if our trade diminishes so that shipowners have no money to spend on new ships, or if the economic conditions of shipbuilding and engineering work in this country become unsound, our yards and factories will have to be closed and unemployment will result.

I shall try to show what financial and economic considerations have to do with our shipbuilding future. Every one is asking: "How long will the present shipbuilding boom last, and what will be the situation when it ends?" The answer is: It will last as long as the following two conditions hold: (*a*) That the world's carrying trade in passengers and cargo needs more tonnage to carry it; (*b*) that we can supply this tonnage at least as cheaply as our foreign competitors. The first of these two conditions is closely related to the financial and commercial standing of our own and other nations. The second depends upon our general economic position, and especially on the efficiency of our shipbuilding and allied industries.

At the suggestion of some of our members I will put before you a few facts which bear on the foregoing. Those who work for wages do so to secure the necessaries of life, and a margin for old age. Consequently, it is not unreasonable that wage-earners should expect their wages, paid in money, to advance in proportion to the cost of commodities so as to enable them to obtain approximately the same standard of comfort, that is to say, their true wages should remain the same. For example, if commodities cost at one time twice as much as at another, it is argued that wages should be doubled. Indeed, it has been claimed that a greater rise than this should be made so that the pre-war standard of living should not only be maintained, but improved. This may appear to be reasonable, and every one must wish it were possible, but the determining factor is: How much can we afford to pay in wages, and, at the same time, carry on our business successfully? If the wages demanded are in excess of what will meet this requirement, the worker has to select between high wages and reduced employment, or lower wages and constant employment. Such a choice is inevitable, and beyond the control of Government, trade unions, or employers.

Formerly, in the coal trade, a sliding scale was adopted, based upon the selling price of coal, and it has been suggested that it would be a great advantage if some method of payment could be accepted whereby the work done would be paid for on a scale varying with the price of commodities.

It is hardly necessary to say that every employer should have the welfare of those in his service at heart, and should wish them to live in the greatest comfort, but whether, under present circumstances, when so many men have lost their lives and their limbs in the war, wage-earners who have remained safely at home should expect to have a higher standard of living than in pre-war days, is a matter out of the province of this paper. Also, whether now, when the country's ability to support the population is dependent upon the maximum possible production, is the time for working hours to be reduced, is likewise a matter which I shall not deal with; but these factors clearly have a great influence on the growth and maintenance of our industries.

Now, when commodity A is exchanged for commodity B, the quantity obtained of B depends upon the value of A equally with that of B at the time of the exchange. For convenience, a standard of value has been recognised in all civilised countries, and our standard of value is gold; consequently, in exchanging gold for commodities, the amount of gold given will depend equally on the value of gold at the time and the value of the commodities then given in exchange. When any special term is used, it is wise for us to agree as to what that term means. Now, when we speak of "the price" of an article we mean "its value measured in gold." There is another term also which I should like to define. When we speak of the "working-man," the term is generally understood to refer only to those who are occupied in the workshop or the yard, which inference does an injustice to the employers and office staff, who are in most cases equally hard-working. Therefore I prefer to use the term "artisan"—a word which every one can be proud of as indicating skill in some trade.

The diagrams (Figs. 1 and 2) are based upon the price of 45 commodities such as are generally needed in civilised life.

Table I gives a list of these commodities.

Fig. 1. MEAN PRICE LEVEL OF 45 COMMODITIES, 1860-1919.

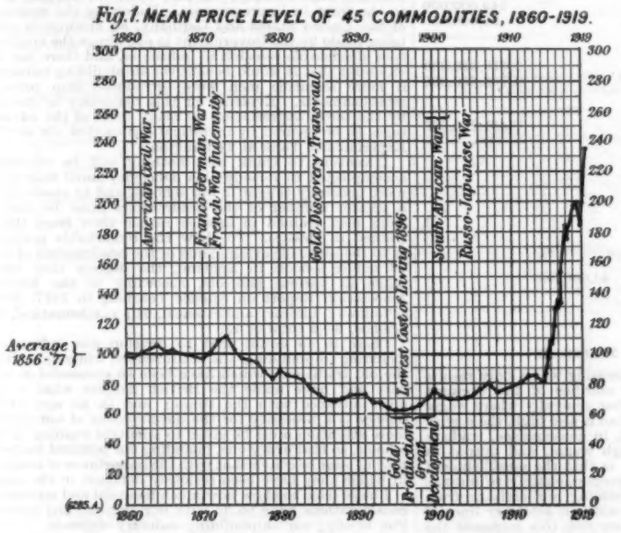
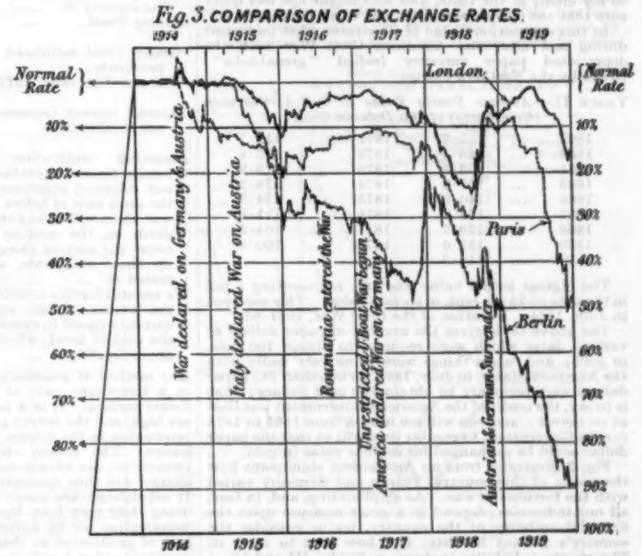


Fig. 3. COMPARISON OF EXCHANGE RATES.



MEAN PRICE LEVEL OF 45 COMMODITIES 1914-1919.

Fig. 2.

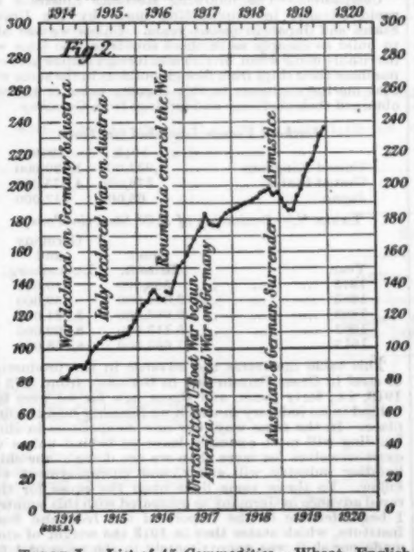


TABLE I.—*List of 45 Commodities.*—Wheat, English; wheat, American; flour; barley; oats; maize; potatoes; rice; beef, prime; beef, middling; mutton, prime; mutton, middling; pork; bacon; butter; sugar, West Indian refining; sugar, Java; coffee; tea; iron, pig; iron, bars; copper; tin; lead; coals, Wallsend; coals, average export price; cotton, middling; cotton, fair; flax; hemp; jute; wool; wool, English; silk; hides; leather; tallow; oil, palm; oil, olive; oil, linseed; petroleum, refined; soda; nitrate of soda; indigo; timber, hewn.

The average price of these commodities forms a fair indication of the purchasing power of currency, formerly of gold, and latterly of paper. The spots on Figs. 1 and 2 indicate the average price of the 45 commodities during each period dealt with, and the figures corresponding to these spots are known as Sauerbeck's index figures. The spaces between the vertical lines represent a year. It will be seen that the curve in Fig. 1 commences at 1860, and terminates at the end of 1919. Prior to 1914, it will be seen that prices did not fluctuate violently. From the commencement of 1914 (Fig. 2) the spaces embrace the period from the beginning of the war up to the end of 1919, during which time violent changes in price took place. Number 100 on Figs. 1 and 2 is taken as representing the average price of the 45 articles during a period extending from 1856 to 1877, and the horizontal line may be considered a datum line. As prices rose and fell from time to time, the spots were above or below that line.

It will be seen that the cost of the 45 articles gradually fell from 1860 to 1896, when it dropped to the level of number 62; that is to say, the commodities purchased with gold in 1860 for 100*l.* could be purchased in 1896 for 62*l.* At this period the cost of living (measured in gold) was at its lowest. The above drop in price was due, in a great measure, firstly, to the increased output per man owing to modern methods of manufacture, and secondly, to better means of bringing raw material and food from abroad in consequence of the development of the mercantile marine.

Four Chief Causes which have led to the Present High Prices.—1. From 1896 to 1914 the curve runs gradually upwards. Prices rose, mainly owing to the huge output of gold from the Cape, causing the value of gold to drop and prices to rise.

2. From 1914 prices rose rapidly owing to scarcity of commodities. This was due: (*a*) To the reduced amount of shipping to bring goods from abroad; (*b*) to industries which formerly produced the necessaries of life being diverted to making war material; (*c*) to a large proportion of the producing population going to the Front, so that the production of the necessaries of life was still further diminished. This scarcity, and the consequent high cost of living, will continue until the world's productivity meets the world's demand.

3. Owing to the increased cost of living, wages were advanced, and this was artificially stimulated by the policy of the Government in taking the line of least resistance and imposing upon controlled establishments increases in wages apparently without considering future economic results. These advances in turn forced up prices.

4. Another cause of high prices is the withdrawal of gold from circulation and the substitution of paper currency. Before the war, this paper could always be exchanged for gold equal to its face value, and the foreigner did not care whether he had gold or paper. Owing to our not having now in the Treasury enough gold to meet our notes, and owing to our continuing to get more and more into debt, foreigners begin to look with some suspicion upon our paper currency, and to require in exchange for their goods a larger amount in paper money than they would have been content with if paid in gold. The position is well illustrated by the fact that at the end of last January 100 sovereigns (or an equal weight in gold) could be exchanged in New York for 486 dollars, while 100 *l.* Treasury notes would only fetch 350 dols. This depreciated value of our paper currency caused an increased cost, measured in paper currency, of those commodities which we buy from abroad, resulting in a further rise in prices.

Before finishing with the diagram (Fig. 2) it is of interest to notice the sensitiveness of the line to incidents during the war. For example, soon after unrestricted U-boat warfare began the cost of living went up suddenly. When the United States joined the Allies, and their chances of success improved, the line took a sudden downward turn. Then, again, at the time of the

* Paper read before the Institution of Naval Architects, March 25, 1920.

armistice, it was thought by many that prices would rapidly adjust themselves, and prices went down. It will, however, be seen that from the early part of 1919 to the end of that year the curve rose rapidly.

What Prospect is there of Prices Falling?—Firstly, if the world's production of gold continues to increase as in recent years, there is reason to expect that, had there been no war, prices would have risen from what they were at the end of 1913, and that the line, which rose from 1896 to 1914, would have continued to rise more or less in the same direction. Secondly, if we can remedy the deficiency of communication with foreign countries by the supply of additional tonnage, then, as ships are built and freights reduced, prices will drop. Thirdly, if the high cost of production is diminished, and the cost of living thereby reduced, prices will drop. But we cannot expect much relief from the present high cost of living until the disappearance of the existing widespread social and industrial unrest. Fourthly, prices will fall as soon as our paper currency can be exchanged for gold, as foreigners will then accept less in gold for their goods than if paid in depreciated paper currency. This depends upon our Government withdrawing their paper in order to re-establish their credit. To make clear what is meant by the depreciation of our paper currency, it may be compared to my giving a cheque for, say, 1,000*l.* to a person who knew I only had 100*l.* to my credit at the bank, and who might not feel quite sure that the cheque would be met when presented.

In this connection Table II illustrates what happened during and after the American Civil War with the depreciated paper currency (called "greenbacks") issued by the Northern States.

TABLE II.—*Average Yearly Value in U.S.A. Currency (Greenbacks) of* 100 *Dols. in Gold.*

1862	...	113·3	1871	...	111·7
1863	...	145·2	1872	...	112·4
1864	...	203·3	1873	...	113·8
1865	...	157·3	1874	...	111·2
1866	...	140·9	1875	...	114·9
1867	...	138·2	1876	...	111·5
1868	...	139·7	1877	...	104·3
1869	...	133·0	1878	...	100·8
1870	...	114·9			

The highest actual value was 285, representing a fall in the note to 35 per cent. of its face value. This occurred in July, 1864. Duration of the Civil War, 1861–65.

The above table gives the number of paper dollars at various dates which were required to obtain 100 dols. in gold; and, when things were going very badly with the Northern States, in July, 1864, no less than 285 paper dollars were necessary to obtain 100 gold dollars; that is to say, the credit of the American Government was then at its lowest; and you will see it took from 1865 to 1878 for the Government to recover its credit so that the paper dollar could be exchanged for its face value in gold.

Fig. 3 illustrates from an Amsterdam standpoint how the credit of this country, France and Germany varied with the fortunes of war. As shipbuilding, and, in fact, all our industries, depend in a great measure upon the financial stability of the country, let us consider the country's present liability, and how best to meet it. The country's liability is shown in Tables III and IV.

To endeavour to arrive at the turning-point when our revenue will be equal to our expenditure, it is clearly evident we must reduce all expenses such as naval and military expenditure (estimated by the Treasury at 1,434,910,000*l.*), which is mainly in the hands of the Government; but it rests also with every one to work hard and to make our exports equal our imports, and thus endeavour to blot out the 669,000,000*l.* representing what we are annually purchasing from abroad in excess of what we are sending in part payment; and, if possible, ultimately, as in the United States and in many countries, to export more than we import. Unless we supply sufficient manufactured goods to the markets of the world in payment of what we need from abroad, foreigners will decline to supply us with foodstuffs and raw material, or will only do so at very high prices, which will lead to scarcity, and to even still higher prices. This is what is taking place at the present time.

The only way to secure for the artisan continuous employment at good wages is for every man to do his best and be paid in proportion to his efficiency, and in this supposed free country we should insist that every one shall be free to work when and as he chooses.

TABLE III.—*Estimated National Expenditure in* 1919–20.

	£
National Debt services	360,000,000
Payments to local taxation accounts, &c.	9,763,000
Land settlement	5,000,000
Other Consolidated Fund services ...	1,832,000
Army	287,000,000
Navy	149,200,000
Air Force	66,500,000
Civil Services—	
Public education	38,841,000
Old-age pensions	17,892,000
Ministry of Pensions	72,855,000
Insurance, &c.	13,435,000
Civil demobilisation and resettlement	30,874,000
Loans to Dominions and allies ...	87,500,000
Railway agreements	60,000,000
Bread subsidy	50,000,000
Other Civil Services	74,407,000
Add: Supplementary Estimates to be presented	60,000,000
Customs and Excise and Inland Revenue Departments	8,537,000
Post Office Services	41,274,000
Total	1,434,910,000

TABLE IV.—*Present Annual Expenditure.*

	£	£
Treasury Estimate of the national expenditure for the year 1919–20		1,434,910,000
To this total we have to add the value of what we import in excess of what we export, the difference being what we owe to the various countries from which our imports come. According to the Board of Trade returns for last year this amounts to...	669,000,000	
From this we are entitled to deduct what are called "Invisible Exports," but which would be better termed "estimated revenue made abroad by British owners and by British shipping and remitted to this country," which is estimated at	520,000,000	
Leaving a balance against this country of		149,000,000
Sinking Fund...		36,000,000
Grand Total estimated expenditure		1,619,910,000
Estimated revenue, 1919–20		1,168,650,000
Annual present increase of our indebtedness ...		451,260,000
Assuming emigration to foreign countries (excluding our colonies) continues at the same rate as before the war, there will be an annual drain on the country to cover the cost of bringing up those emigrants, estimated at	40,000,000	
We are still further in debt to the extent of the paper currency issued in excess of the gold in hand, which is approximately	300,000,000	

Any method of artificially increasing wages only results in a temporary gain at the sacrifice of the worker's future welfare. It is a fact that generally where wages are high, and the output per man is also high, the cost of production is the lowest, and, in consequence, trade is secure. The reason why high wages, and output in proportion, are advantageous, is that the establishment charges are thus diminished proportionately to output. If regulations are made restraining our artisans from doing their very best, by insisting on arbitrary lines of demarcation, or by reducing output, this increases the cost of production so that the lead in shipbuilding will pass into other hands, and a very heavy responsibility will rest upon those who make such regulations.

Competition.—The following statistics illustrate the rapid advance in shipbuilding made by the United States and Japan in recent years. Unless we are able to build as cheaply as in these countries, the time will inevitably come when British and foreign shipowners will purchase their ships from foreign builders in the same way that marine engineers in this country prior to the war obtained their shaftings and forgings from Germany.

Merchant Vessels Launched (in Tons).

	1913.	1919.
United Kingdom ...	1,932,000	1,620,000
United States	276,000	4,075,000
Japan	65,000	612,000

TABLE V.—*Production of Mild Steel (in Tons).*

Year.	Great Britain.	Germany and Luxemburg.
1873	588,000	310,000
1883	2,041,000	859,000
1893	2,983,000	2,231,000
1903	5,113,000	8,669,000
1913	7,663,000	18,958,000

This table illustrates the advance in the production of steel in Great Britain and in Germany from 1873 to 1913, *i.e.*, forty years, and shows how far we were left behind in an industry in which we formerly held the first place. In the same way, our new competitors in shipbuilding will most certainly leave us behind unless we exert ourselves far more than we are doing; our shipbuilding industry will suffer, and unemployment will follow. To throw some light upon the cause for this rapid advance in Germany as compared with this country, I beg reference to the Report of the Iron and Steel Institute, which states that in 1913 the weight of steel made per shift was approximately in the ratio of 1 for England, 1·5 for the United States of America and 2 for Germany, that is to say, the output per head in Germany was twice that of England.

I should like to say a word about the 40,000,000*l.* put down as the cost to this country of emigration. People often speak of emigration as "a blessing, finding employment for the surplus population." To feed, clothe, and educate from infancy those who ultimately emigrate to foreign countries is a clear expense to us. Assuming, in round figures, that 100,000 leave us annually to go to foreign countries (excluding the Colonies), and assuming that an emigrant costs 400*l* to bring up, we are actually incurring an annual expenditure of 40,000,000*l.* per annum for the benefit of other countries, and in some cases raising up future competitors. For example, in the United States we find at least one-half of the shipyards controlled by men from the Clyde and the Tyne.

In the United States and Germany, before the war, industries were developed with such rapidity that employment was found for even a greater number of people than the natural increase of the population, and immigration took place on a considerable scale into the United States and into Germany; while in this country our industries and trade did not keep pace with the increase of the population, and emigration was the result. Emigration from a country is an indication that industries are not being developed there at the same rate as the increase of population while immigration indicates the reverse.

The only way to reduce the 40,000,000*l.* sterling per annum drain on this country due to emigration is to do our utmost to increase our trade, so that people may find here profitable employment, which is dependent, as in the United States and Germany, upon developing our industries. Not only must we seek to produce cheaply, so as to secure trade, but we must not neglect the encouragement of science and research, because our prestige as a shipbuilding country depends not only upon building ships cheaply, but also upon our keeping well to the front in improvements. Following the example of the United States and Germany, an attempt is now being made by the Government to encourage the application of scientific research to industries, and there can be on doubt that it would benefit the shipbuilding industry if more scientific men were introduced into private establishments. Evidence of this deficiency is proved by the tardy appreciation by many firms of the advantages to be secured by investigations carried out at the Experimental Tank at Teddington.

I venture to think that nothing will be seriously accomplished to remedy this deficiency until science is more generally taught in our schools, and to ensure this a greater number of the headmasters must be drawn from men trained in science rather than from those trained in classics. To show the remarkable position as to the scientific attainments of the headmasters of the 73 public schools in England, the degrees they have taken in various subjects, according to the British Association Report on Science Teaching in 1917, were as follows: Literary and classical, 61; mathematical, 9; Science, 3—a total of 73.

There is no doubt that to develop our industries, including shipbuilding, the headmasters, while upholding the old traditions, which have been so successful in the past and have made the British Empire what it is, must advance with the times; and in an age when science is a necessity for the development of our trade, more attention must be given to scientific training in all schools, so that every one, including our political leaders, may at least be conversant with the importance of science, in which they have been seriously deficient in the past.

I have tried to show how much financial and economic considerations have to do with our shipbuilding future. Put briefly, our shipbuilding industry depends:—

1. Upon our shipbuilders being able to produce ships cheaper than our competitors, and shipowners being able to order ships from us instead of from abroad.

2. Upon our keeping well to the front in naval architecture, which is greatly dependent upon scientific research.

3. Upon our having in view that among our present competitors are the United States and Japan (and, later on, Germany), where the most up-to-date equipment is to be found in their shipyards and engine works. We must therefore adopt the most modern machines, and, where old ones exist which are costly to work, take Lord Fisher's advice and "scrap the lot."

Further, I think many firms might take more interest in the welfare of those in their employ, and by extending more human sympathy towards them in their daily business life inspire mutual confidence. This I believe is mainly to be obtained by personal intercourse between employers and employed, and it rests with the former to secure this end. I would once more call attention to the heavy responsibility that rests upon those who make restrictions on labour, which restrain our artisans from doing their very best, by insisting on arbitrary lines of demarcation, or by reducing output, or by preventing those who can and are anxious to work—both men and women—from so doing, and thus render it impossible in the future for our shipbuilders to meet foreign competition. In face of these facts, for any one to imagine that by limiting output we are adding to our prosperity is inconceivable. This view, I feel sure, is not shared by the better-informed British working man, for the vast majority are men of intelligence, and when they come to a full realisation that slackness will not only imperil the nation, but will injure their fellow-workers, they will, I feel certain, respond to the demands made upon them.

FURTHER NOTES ON THE DIMENSIONS OF CARGO STEAMERS.*

By JOHN ANDERSON, Member.

IN 1918 the writer had the honour of reading a paper before this Institution on the most suitable sizes and speeds of general cargo steamers, and it was then indicated that, to obtain the best financial results from such steamers, working under unrestricted conditions of draught and of quantity of cargo available, the dimensions, or total capacity of the vessel should be in some proportion to the ratio of steaming time to total time

* Paper read before the Institution of Naval Architects, March 25, 1920.

on service and also to the speed of the vessel. The statement was then made that large dimensions, coupled with the greatest economy, were dependent upon either a relatively long voyage or a rapid system of loading and discharging. The present notes are an extension of the former paper, and are intended to indicate the best proportions of depth and breadth for the lengths already obtained, under different conditions of loading and length of voyage.

General.—It is known that the cost of a vessel is reduced per ton of deadweight as the $\frac{\text{length}}{\text{depth}}\left(\frac{L}{D}\right)$ ratio is reduced; also, and particularly in low-speed vessels, that the power and fuel consumption is reduced per ton of deadweight as the disposal of displacement is increased depthwise. It is, therefore, obvious that a relatively short and deep vessel would be the most profitable on a long voyage.

A vessel of large displacement might be found proportionately profitable on a relatively short voyage, but such a displacement could only be justified by a very rapid "turn round," or cargo-handling speed. This factor would be largely influenced, in many cases, and particularly in vessels with slow-discharging units, by the lineal fore and aft distance available for working the cargo. It is, therefore, conceivable that, to obtain the best results on a short run for vessels whose time in port is fixed entirely by the time required for loading and discharging cargo, it might be found advantageous to sacrifice some of the advantages claimed for deep ships on long runs by disposing the displacement lengthwise, so that additional cargo gear could be arranged per unit of cargo. Such a disposition as this has been practised in the design of vessels carrying ore on the great lakes of America (notably the Horace S. Wilkinson, the dimensions of which are 588 ft. by 60 ft. by 32 ft., which gives a $\frac{L}{D}$ ratio of 18·4), also for vessels engaged on the coastal trades of South America and China.

In order to ascertain the extent to which proportions should be varied for vessels engaged on voyages of varying duration and for different loading speeds, calculations have been made for vessels having what are considered the minimum lengths of erections, *i.e.*, a short poop and forecastle and a bridge covering the machinery casings and the officers' accommodation. Vessels with such erections will probably represent the cheapest type of seaworthy cargo carrier, and will have, at the same time the maximum amount of flush deck length for the working of cargo.

The results presented in the writer's earlier paper were for vessels of the "well-deck" type, having erections covering 50 per cent. of the length, with $\frac{L}{D}$ ratios of $13\frac{1}{2}$ and with breadths of one-tenth of the length + 12 ft.

Basis of Investigation.—The lengths now used are the same as those adopted in the paper referred to, viz., 250 ft., 330 ft., 410 ft. 490 ft., and 570 ft., and the corresponding breadths are the same. Alternative ratios for $\frac{L}{D}$ of 11 and 15 are now used, and it is submitted that these, combined with the earlier calculations, will give the desired information.

With such changes of depth there will be an excess of stability in the case of the shallow vessels, and a deficiency in the case of the deep vessels. On this account additional calculations have been made to show the effect of adopting a breadth of $\frac{L}{10}$ + 8 ft. for the shallow vessels and a breadth of $\frac{L}{10}$ + 16 ft. for the deep vessels. These additional calculations have been made for several conditions, and are shown on Fig. 3, below, for speeds of 10 knots and 14 knots and a voyage of 1,000 nautical miles.

It should be noted that a $\frac{L}{D}$ ratio of 15 is considerably in excess of that allowed by the classification societies for seagoing tonnage with normal scantlings, but, by the courtesy of the Chief Ship Surveyor of Lloyd's Register, it has been possible to ascertain the probable minimum scantlings which might be accepted for that Society for future vessels should such proportions be found advantageous.

The calculations have been made for distances of 600, 1,000, and 4,000 nautical miles and for speeds of 10 knots, 12 knots, and 14 knots.

In the earlier paper the time in port was calculated from the number of winches and derrick systems which could be worked at each cargo hatch, and upon assumed working speeds for that type of cargo gear, but as the distance between each ordinary cargo hatch is approximately the same for each size of vessel, it was decided in this case to calculate the time in port as proportional to the lineal feet of deck available for working short hatches through which the cargo is worked by continuous cargo gear. Alternative calculations have been made for loads 6 tons, 12 tons, 20 tons, and 34 tons per lineal foot per day. In order to show how these loads compare with the earlier calculations, Fig. 1, herewith, has been prepared, which shows the comparative values given by ordinary derrick gear, and it will be seen that the varia-

Fig. 1. TO SHEW THE LOADING SPEED PER LINEAR FOOT OF DECK GIVEN BY THE DERRICK SYSTEMS WHICH WERE ASSUMED FOR THE 1918 PAPER

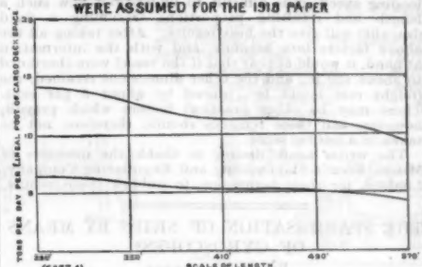


Fig. 2. 600 NAUTICAL MILES & 6 TONS PER LINEAL FT PER DAY

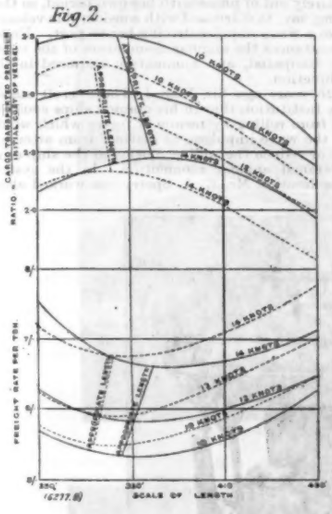
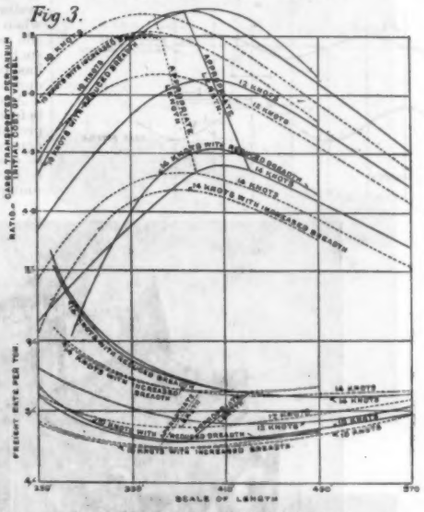


Fig. 3. 1000 NAUTICAL MILES & 20 TONS PER LINEAL FT PER DAY



NOTE:—FULL LINES ON DRAWING REFER TO AN $\frac{L}{D}$ RATIO OF 15, AND THE DOTTED LINES TO A RATIO OF 11

Fig. 4. 4000 NAUTICAL MILES & 6 TONS PER LINEAL FT PER DAY

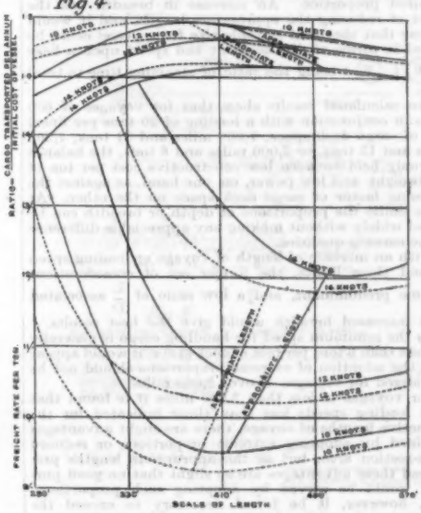


TABLE I.

Length of Vessel.	Total Tons Handled per Day. At 6 Tons per Foot.	At 12 Tons per Foot.	At 20 Tons per Foot.	At 34 Tons per Foot.
ft.				
250	780	1,560	2,600	4,420
330	1,175	2,350	3,920	6,650
410	1,560	3,120	5,200	8,840
490	1,890	3,780	6,300	10,700
570	2,190	4,380	7,300	12,400

TABLE II.—TO SHOW THE FREIGHT RATES AND TONS CARRIED WITH AN $\frac{L}{D}$ RATIO OF 15, IN COMPARISON WITH VESSELS OF $\frac{L}{D}$ RATIO 11, THE BASIS OF THIS TABLE BEING 100 PER CENT. FOR THE LATTER PROPORTION IN EACH INSTANCE.

Condition.	10 Knots. Loading Speed per Lineal Foot of Cargo Space per Day. 6 Tons. Freight Rate.	6 Tons. Tons Carried.	20 Tons. Freight Rate.	20 Tons. Tons Carried.	14 Knots. 6 Tons. Freight Rate.	6 Tons. Tons Carried.	20 Tons. Freight Rate.	20 Tons. Tons Carried.
600 *Nautical Miles.*								
Appropriate length	97	107	99	105	97	104	99	105
85 per cent. appropriate length	99	107	100	106	102	100	102	104
115 per cent. appropriate length	94	112	96	106	94	114	96	111
1,000 *Nautical Miles.*								
Appropriate length	103	101	100	101	97	104	100	104
85 per cent. appropriate length	105	98	103	96	106	97	105	94
115 per cent. appropriate length	101	103	102	106	92	112	99	105
85 per cent. appropriate length and increased beam	—	—	104	99	—	—	106	97
115 per cent. appropriate length and reduced beam	—	—	101	106	—	—	98	105
4,000 *Nautical Miles.*								
Appropriate length	103	98	109	82	103	99	110	86
85 per cent. appropriate length	105	91	109	82	107	90	110	86
115 per cent. appropriate length	103	101	109	82	103	101	110	86

These additional calculations have been made for several vessels of the "well-deck" type, and for speeds of 10 knots and 14 knots, and the results are shown in Table II. The H value, which was defined in the earlier paper, and is the distance through which the cargo has to be transported. Table I also indicates what the total lifting power per day is under these new assumptions.

The variation given by the H value might be taken for all the cargo-handling gear which is generally in use, such as derricks, cranes or grabs. With special appliances such as grain elevators, the "Donald" type of

cargo transporter, or other similar appliances, which have continuous discharging facilities, a uniform rate per lineal foot such as is now proposed would, however, be most applicable.

The bases used for initial cost, allowances for holidays and repairs, depreciation, fuel consumption, profit, tonnage dues and wages are exactly similar to those used in the earlier paper, and it is assumed that if present-day figures were substituted they would not alter the relation of these factors to each other, but, in any case, it is submitted that the earlier calculations have shown that moderate variation in any one item will not seriously affect the result which is sought.

Curves for the various conditions have been drawn (and some of these are illustrated on Figs. 2, 3, and 4, page 461), giving values respectively for 600 nautical miles and 6 tons per lineal foot, for 1,000 nautical miles and 20 tons per foot, and for 4,000 nautical miles and 6 tons per foot per day.

The final results have been again expressed in terms of "freight rate" for a fixed amount of profit on the invested capital, and of "tons carried per annum" in relation to the initial cost of vessel.

Results.—By drawing the appropriate length line for each condition which comes within the limits of 570 ft. length, at a position midway between the highest point of the "tons carried" curve and the lowest point of the "freight rate" curve, it is found that for a difference of $\frac{L}{D}$ ratio of 4 there is a difference in appropriate length of about 8 per cent. at 10 knots and 12 per cent. at 14 knots, the shallower vessels being the longer. The appropriate lengths given in the earlier paper for a ratio of 13½ can, therefore, be used and corrected for any required proportion. An increase in breadth has the effect of reducing the appropriate length, and it would appear that the most suitable size for a vessel could be stated in terms of displacement and speed upon a base of $\left(\frac{E}{4}\right)$, $\left(\frac{E}{t}\right)$ t being the ratio of steaming time to total time.

The calculated results show that for voyages of 600 miles in conjunction with a loading of 30 tons per lineal foot of cargo deck space, 1,000 miles and 21 tons, 1,500 miles and 13 tons, or 2,000 miles and 6 tons, the balance is evenly held between low constructive cost per ton of deadweight and low power, on one hand, as against the opposing factor of cargo deck space on the other. At these limits the proportions of depth or breadth can be varied widely without making any appreciable difference in the earning qualities.

With an increase of length of voyage or loading speed beyond these limits, the former set of considerations become predominant, and a low ratio of $\frac{L}{D}$ associated with increased breadth would give the best results.

As the minimum speed for handling cargo is generally not less than 6 tons per foot of deck space, it would appear that the adoption of extreme proportions should not be considered for voyages of over 2,000 miles.

For voyages of less than 2,000 miles it is found that with loading speeds less than those indicated for the respective lengths of voyage, there are slight advantages obtained by adopting extreme proportions or reduced cross-section area, but at the appropriate lengths prescribed these advantages are so slight that no good purpose would be served by adopting such proportions.

If, however, it be found necessary to exceed the appropriate length as defined under these conditions, it may be then found more profitable to reduce the cross-section area for vessels which are fitted with slow-working cargo gear. If, on the other hand, a length which is less than the appropriate length is decided upon, an increase of cross-section area will be advantageous. Figs. 2 and 3, page 461, bear out these remarks, and show that on the left-hand side of the appropriate length line increased cross-section area will give increased earning power, while on the right-hand side such increases will reduce it.

This statement is borne out by the additional lines which are shown on Fig. 3, to illustrate the effect of modification of breadth.

In giving these results the writer considers it desirable to repeat that, if a vessel is required to make a return voyage in ballast trim, the ballast run should be considered as an extension of the main voyage, and that this consideration will have a bearing upon the proportions to be adopted. Similar remarks may be applied to vessels whose time in port is not fixed entirely by the time required to handle cargo.

It is not conveniently possible to show all the results of the calculations made, but in order to indicate the differences produced by change of proportions and cargo-handling speed, Table II has been prepared for loading speeds of 6 and 20 tons, and it gives the values, as a percentage, for a ratio of length to depth of 13 in comparison with that of 11. The results are given for the appropriate lengths and also for 85 per cent. and 115 per cent. of this, and the basis for these figures is 100 per cent. for a length to depth ratio of 11 in each instance. In the case of the vessels with altered breadths, the percentages are based on the increased breadth in the short vessels and the normal breadths in the long ones.

Conclusions.—It would appear that extreme proportions could not be justified for vessels on voyages of over 2,000 nautical miles unless by restricted depth of water, and if this restriction exists it would be more profitable to increase the breadth than the length beyond normal proportions, provided, however, that such increase did not give an undue excess of stability. Fortunately, extreme proportions would generally be be associated with relatively small vessels, and in such it is a comparatively simple matter to add the additional material required to provide the necessary strength. For convenience in calculation the differences have been estimated in terms of length and depth, but it will be understood that when the breadth instead of the depth can be reduced, in vessels with extreme proportions better results will be obtained.

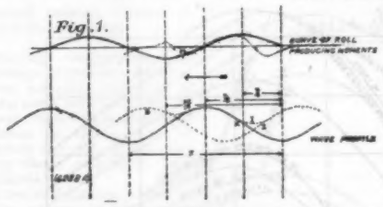
The proportions of the Horace S. Wilkinson have already been alluded to, and it is realised that as this vessel is of very special type and construction, it may not come within the scope of these calculations. It is of interest to view its case, however, on the basis of vessels of normal construction, and, considering the length of run, the speed of the vessel and its probable loading speed, it is difficult to understand how such a length and resulting proportions (assuming a fixed draught) will give the best results. After taking all the above factors into account, and with the information at hand, it would appear that if the vessel were shortened to about 430 ft., and the other dimensions retained, the freight rate might be reduced by about 5 per cent. There may be other practical factors which prevail, however, and these remarks should, therefore, not be taken in a critical sense.

The writer again desires to thank the directors of Messrs. Scott's Shipbuilding and Engineering Company, Limited, for their permission to publish these results.

THE STABILISATION OF SHIPS BY MEANS OF GYROSCOPES*.

By P. R. JACKSON.

THE problem of controlling the movements of vessels when under the influence of impulses received from the waves is one which has been dealt with at considerable length in the Transactions of this Society. Previous papers have investigated very fully both the fundamental aspect of the subject, and various mechanical arrangements for stabilising vessels, so that the present paper will only describe some recent developments which demonstrate the practicability of theories previously discussed by the members of this Institution.



In order that the method of operation of this system should be clearly understood, it is necessary that we should thoroughly appreciate and carry in our mind the manner in which a ship with ordinary stability, first commences to roll, and subsequently attains a state of heavy rolling.

The simplest wave system is a long ocean swell, such as is encountered in deep water after a gale, and the profile of such a system of waves probably very closely approached a sine curve. Such a profile is seen in the diagram, Fig. 1, where T represents the period or time of one complete cycle; above this wave profile is shown another curve whose ordinates represent "wave slope," and are constantly proportional to the wave impulses imparted to the ship. It follows that the impulses received by the ship vary in value in accordance with a sinuous curve, and that the maximum values of the roll-producing couple occur at T/4 and 3T/4. In one period T the vessel is subjected first to a gradually increasing impulse from one side, and then after this impulse has died down to zero by a similar impulse from the opposite side, both impulses being produced by one wave. At the instant when the impulse changes from one direction to the opposite the crest of the wave is passing under the keel of the vessel.

Actual wave formations as met with in rough weather, however, do not conform to the profile shown, because the period T does not remain constant for any length of time, and the outline of the wave is nearer a trochoidal form than a sine curve. If the wave has a trochoidal form or something approaching that, the times at which the maximum inclining forces are received are not symmetrical throughout the wave period, but the sinuous character of the impulses still remains. In a confused sea rapid changes in phase of the waves occur, due to several wave systems being imposed on one another. Such a change in phase is shown in the diagram (dotted), Fig. 1, where the wave impulse corresponding to the wave profile shown in solid line is indicated by a corresponding solid line in the curve of roll-producing moments. To indicate the effect of change of phase we have also shown another wave profile (dotted) with its corresponding roll-producing moments dotted in the diagram above.

In order to obtain definite data an instrument, Fig. 2, was constructed to draw a curve of the actual oscillations of a vessel when rolling freely under wave impulses. If we examine one of these diagrams, Fig. 3, we see that the roll gradually increases by comparatively small successive increments, then dies down again, and almost immediately commences to build up again.

These times of increasing roll represent the state of affairs when the period of the wave impulses approaches the natural period of oscillation of the ship, and is in phase with the ship's oscillations; when the impulses become markedly out of phase with the ship's roll the amplitude is reduced. Sometimes a sudden reversal is seen which is caused by the vessel meeting a new wave system entirely out of phase with her own period, so that when rolling, say, to starboard with considerable velocity she receives a wave impulse driving her to port. Under such circumstances the angular momentum of the vessel has to be dissipated, and momentum acquired in the opposite direction.

About 25 years ago Sir John I. Thornycroft stated before this Institution that in his opinion ships could be prevented from rolling by means of forces which would neutralise the wave impulses, as distinct from attempts to destroy or reduce the rolling motion of the ship after it had obtained angular momentum. In the system under consideration Mr. E. A. Sperry has worked along these lines and has produced a machine capable of opposing the roll-producing couples by a series of equal and opposite couples and with practically no lag between the roll-producing couple and the opposing stabilising couple. The magnitude of the forces which have to be impressed on the vessel are comparatively small, amounting only to the magnitude of the impulse received from a single wave as shown in the rolling diagrams. By thus preventing the roll from building up the vessel is maintained within 2 deg. of the vertical.

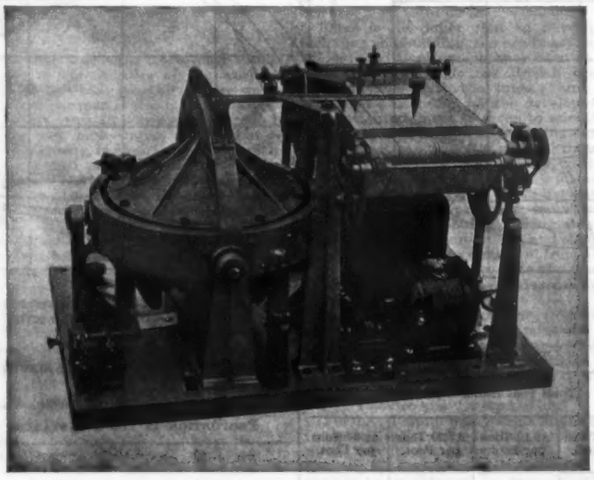


FIG. 2.

Fig. 4 illustrates the system in diagrammatic form. The main stabilising gyro is shown with its spinning axis vertical, and so mounted that it can be precessed in the plane at right angles to the paper by means of the circular rack engaging with the pinion of the precession motor. The direction of spin, precession and resulting couple are shown by the arrows. At the side of the diagram appears a small gyroscope with its spinning axis horizontal. The gyro is so mounted that the slightest acceleration of the vessel in the rolling plane will cause it to precess and close an electrical contact, which, by means of suitable relay switches, operates the main precession motor, and thus causes a stabilising couple to be applied to the vessel just sufficient to neutralise this impulse which was causing the angular acceleration in the rolling plane. Immediately this acceleration ceases the control gyro stops the precession motor and is ready to deal with the next wave impulse.

It is obvious that all gyroscopes sufficiently large to effectively stabilise a vessel must have considerable gyroscopical inertia. It is for this reason that the method

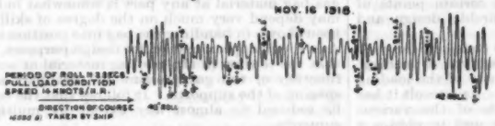
* Paper read before the Institution of Naval Architects, March 25, 1920.

of control is so important, as by its great sensitiveness it enables the wave impulses to be dealt with before the vessel has attained any considerable angular momentum, the precession motor overcoming the gyroscopical inertia and so keeping the stabilising couples in phase with the wave impulses.

The stabilising gyro system may consist of one or two gyroscopes according to the power required. If one gyro only is used it is placed with its spinning axis vertical, and mounted so that it can precess in the fore and aft plane of the vessel. If two gyros are employed their spinning axes are placed horizontal, but the direction of spin of one gyro is opposite to that of the other. The precession plane is also horizontal, but the gyros are precessed in opposite directions, so that the stabilising couples act in the same direction.

The stabilising gyros are designed to apply a roll-quenching couple sufficient to suppress the greatest

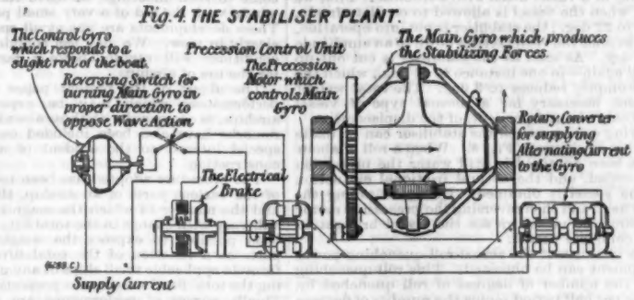
Fig. 3. DESTROYER Nº 114.



of the ship, and the maximum precession angle of the gyro is fixed at from 60 deg. to 70 deg. each side of the centre position. When stabilising a vessel against wave impulses which are just equal to its capacity the stabilising gyro makes one complete movement in the precession plane from, say, 60 deg. one side of the centre position to 60 deg. on the other side in 9/10 of the vessels natural half period, although the vessel will not move more than 2 deg. from the vertical.

This is what occurs when the vessel is receiving successive wave impulses which are constantly trying to

Fig. 4. THE STABILISER PLANT.


The Control Gyro which responds to a slight roll of the boat.
Precession Control Unit
The Precession Motor which controls Main Gyro
The Main Gyro which produces the Stabilizing Forces
Reversing Switch for turning Main Gyro in proper direction to oppose Wave Action.
Rotary Converter for supplying Alternating Current to the Gyro
The Electrical Brake
Supply Current

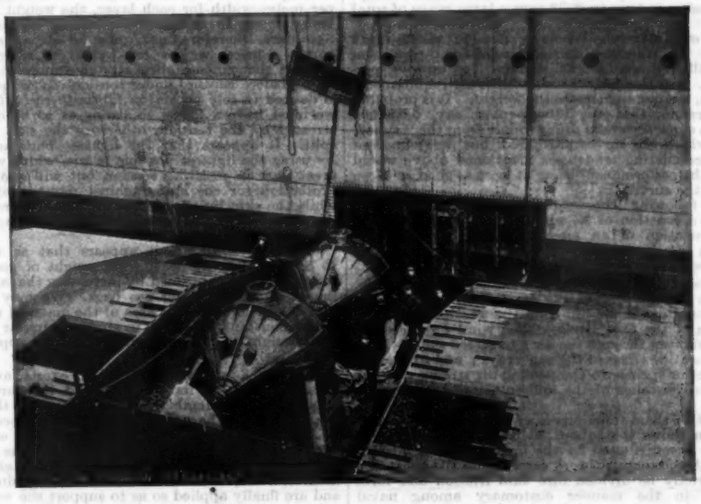


FIG. 5.

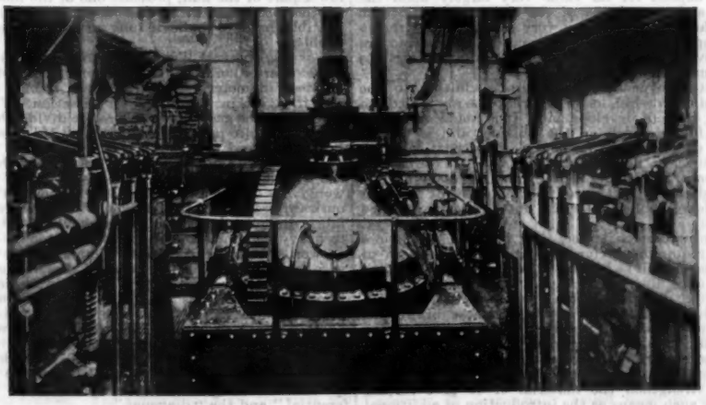


FIG. 6.

The intensity of the stabilising couple is proportional to the velocity of precession, and since the rate and direction of precession are always completely under control and capable of almost instantaneous reversal, we have a source of energy by means of which we can either apply a regular sinuous couple in the exact rolling period of the vessel, or an irregular series of stabilising moments as may be required in order to counteract the roll-producing forces of the waves.

For example, in Fig. 1, if we imagine that the wave system B B suddenly appears in the original wave

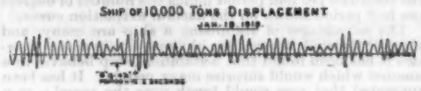


Fig. 7. S. Y ARAMIS

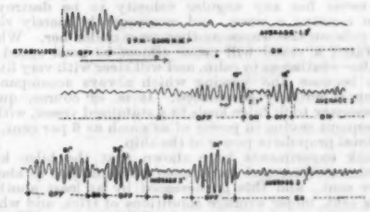
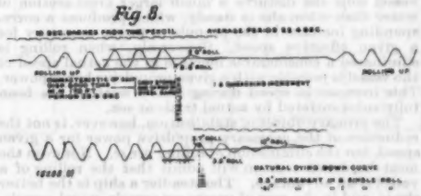


Fig. 8.



system, we would get a state of affairs as indicated. The two systems would, however, tend to merge one into the other approximately as shown. If a vessel was under the influence of the wave profile shown in the full line the direction of the progress of the wave being as indicated by the arrow, on reaching a point X, the roll-producing moment would decrease very rapidly on account of the advancing B wave, until at Y the sign of the moment would be reversed, and the ship would then come under the direct influence of the B wave.

If we now consider the movements of the stabiliser under these circumstances, we see that when the vessel reached the position X, the gyro would be approaching the vertical position in the precession arc, where it would deliver its maximum roll-quenching couple. Immediately the roll-producing moment decreased in value the rate of precession would be checked until the gyro would come to rest at about the same instant as the vessel reached the position Y. The direction of precession would then be reversed, although the gyro might only have precessed for about 10 deg. past the vertical position. The vertical position of the gyro would again be reached at about the position Z, and the precession would then be carried on at the ordinary rate to counteract the gradually decreasing moment produced by the B wave.

Having considered the principles on which this system is based it will be interesting to examine the mechanical details of some actual equipments. For a 10,000-ton steamer two cast-steel wheels were used, each 9 ft. in diameter, and each weighing about 25 tons. This steel casting must, of course, be accurately machined all over and accurately balanced, both statically and dynamically, which is done by means of balancing plugs. The rotor disc is not pierced in the centre, but is attached to its shaft stubs by means of collar studs. One of the shaft stubs carries the rotor of a three-phase A.C. motor for spinning the wheel, the stator being attached to the gyro casing which is made in four pieces, two forming an annular section surrounding the rim, and two conical end-pieces carrying the rotor bearings. The peripheral speed of the wheels is about 500 ft. per second, and in order to reduce the driving power the wheels run in a partial vacuum. It is impossible to exceed the designed speed because the speed of this type of motor cannot be increased to any appreciable extent above the designed

single increment of roll that the waves would produce under conditions of free rolling. This couple must be proportional to D H sin α, and be applied throughout the ship's natural period, where α = effective wave slope. Consequently the capacity of the stabilising equipment must be proportional to D. T. H., where

D = displacement of vessel,
T = period of one complete oscillation,
H = metacentric height, or G.M.

As we have seen, the couple produced by the wave changes in value according to a sinuous curve, and attains its maximum values at times (about) T4 and 3 T/4; the gyro control system is consequently arranged so that the stabilising gyro will exert the maximum value of its roll-quenching couple at the same instant. The precession velocity of the gyroscope is in practice, made about 10 per cent. greater than the rolling velocity build up a roll. Now, suppose the vessel meets a new wave system of a different phase. Since the stabilising gyro is always under complete control, it will immediately adjust its precession so as to correspond with the new wave phase.

If the impulses received from the waves are less than the couple which the stabiliser can exert for a full precession, the control gyro automatically reduces the arc of precession, and as soon as any single impulse has been neutralised the precession is stopped. If an exceptionally large wave should encounter the ship and produce an increment of roll beyond the capacity of the stabiliser, the result will be an inclination of the vessel proportional to the excess of the wave couple over the gyro couple, but this inclination will be eliminated by the next precession of the gyro, as it is found in practice that these exceptional waves are only encountered singly, and are usually followed by waves of much smaller size.

limit. The whole load is friction, so the apparatus cannot, under any circumstances, "race."

Fig. 5, showing the two stabilising gyros being put on board the vessel and the precession bearings on the top of the gyro casings, illustrates the relative size of the ship and stabiliser.

Fig. 6 shows a small installation in a yacht of about 230 tons displacement, the control gyro being clearly shown above the stabilising gyro.

The wonderful flexibility of the Sperry system is shown in the curves, Fig. 7, which is an autographic record of the behaviour of a vessel fitted with a stabiliser. First we see the roll when the vessel is allowed to oscillate freely, amounting to 22 deg.; the stabiliser is put into operation, and almost at once the vessel settles down to an amplitude of about 2 deg. As soon as the stabiliser is cut out up goes the roll again—in one instance to 31 deg., which the stabiliser promptly reduces to 3 deg. The total weight of equipment necessary for a normal type of vessel amounts to only about 1 per cent. of the displacement.

By throwing over a switch the stabiliser can be made to roll the ship as shown in Fig. 8. When a roll of about 10 deg. has been obtained in still water the precession motor is stopped, and the natural frictional extinction curve of the vessel is obtained. By again rolling the vessel to 10 deg., and then reversing the precession motor and stabilising the vessel we see the vessel brought to rest in one complete period.

By means of this test the actual roll-quenching power of the equipment can be obtained. This roll-quenching capacity is the number of degrees of roll quenched by the stabiliser per half period minus the number of degrees per half period shown on the natural extinction curve.

The advantages of stabilising a ship are many, and some of these advantages are obvious, but in actual practice it has been found that a stabilised ship behaves in a manner which would surprise many people. It has been suggested that seas would break over the vessel; as a matter of fact exactly the reverse is the case, the vessel becoming dry and much more seaworthy simply because she never has any angular velocity to be destroyed when meeting a wave, and consequently merely rises and falls on the waves as they pass under her. When stabilised a vessel will make almost as good speed in rougher weather as in calm, and will steer with very little helm because the yawing which always accompanies rolling is entirely eliminated. It is, of course, quite unnecessary to fit bilge keels to a stabilised vessel, with a consequent saving in power of as much as 6 per cent. of the total propulsive power of the ship.

Tank experiments have shown that the bilge keel resistance of a vessel on an even keel amounts to about 4 per cent., and this is increased by at least another 2 per cent. under average conditions of trim, and when the vessel is pitching to even a slight extent. When a vessel rolls she disturbs a much larger cross-section of water than when she is steady, which produces a corresponding increase in the propulsive power necessary for a given effective speed. Conversely, when rolling is eliminated a considerable increase in the actual speed of the vessel is possible with a given propulsive horse-power. This increase in speed during heavy weather has been fully substantiated by actual trials at sea.

The primary object of stabilisation, however, is not the reduction of the necessary propulsive power for a given speed, but the elimination of rolling *per se*. Not even the most hardened seaman will admit that the rolling of a vessel is an advantage. The steadier a ship is the better she is, and in the case of passenger vessels, naval vessels, and those ships which carry live stock, the advantage of being able to maintain the vessel practically on an even keel under all conditions is enormous.

The great interest which has been exhibited in all attempts to eliminate rolling are sufficient evidence of the value of a steady ship, and the Sperry system has proved that it is entirely practical and successful in operation. Installations in actual use ranging from vessels of 150 tons displacement to 10,000 tons have demonstrated that this system is no longer in the category of an experiment but that with a very moderate weight of equipment a vessel may be maintained within 2 deg. of the vertical, the power necessary for operating the equipment being a mere fraction of the energy dissipated by the extra resistance caused by the free rolling of the ship under the action of the waves.

THE EFFECT OF SIZE UPON PERFORMANCE OF RIGID AIRSHIPS.*

By C. I. R. CAMPBELL, R.C.N.C., Member, and H. MAY, R.C.N.C.

IT is inevitable that those who do not happen to be closely associated with the development of rigid airships should base their estimates of the possible value of such craft upon the performances of existing rigid airships under present conditions. A true estimate should, however, be based upon a study of the probable utility of future airships under the conditions which may be expected to prevail in the future. While not admitting, by any means, that airships have not yet reached a stage of development in which they can be employed very usefully for various purposes, commercial and military, it is felt that the chief work to be done at the moment is to improve our knowledge and resources so that we may be able to take the fullest advantage of the conditions which will exist in, say, three or four years' time.

A consideration of the progress which has been made in the use of aeroplanes for the transport of mails, passengers and packages under the unfavourable conditions which have prevailed since the armistice, indicates clearly that we are entering upon a period when travel by air will become more and more customary, and when it will be realised more generally that the investment of money in air travel concerns is a reasonably safe and lucrative proceeding. Another point of great importance is that we shall certainly be able in a few months to provide mooring masts or other appliances of a similar nature which will render it unnecessary for airships to be handled on the ground except for extensive overhaul or large repairs. Airships, in fact, will but rarely come to ground at all, and they will be able to come to their moorings, or leave them, in all ordinary winds, with the aid of a very small party of attendants. These developments are not at all speculative, they are clearly in view. We may feel confident, therefore, that conditions will rapidly become far more favourable for the use of airships.

The object of the present paper is to indicate the performances which may be expected from future airships, as compared with those already attained. A few remarks have also been included on certain points of special interest to the student of airship design and construction.

The procedure adopted has been to consider, for each of the various parts of an airship, the type of loading, and the manner in which the magnitude of the loading will vary with change in the total lift. As a result it has been possible to express the weights of the various parts as a function of the total lift, and to obtain a formula applicable to all ships of any given type, expressing the total fixed weight as a proportion of the total lift. Finally curves of performance are given for airships nearly similar in type to R 38 over a large range of total lift.

These curves must, however, not be taken quite literally. With increase in size of airships many improvements will become feasible, tending to improve performance. On the other hand, additional requirements may arise, tending to increase the weight. It is probably true, therefore, that any airship over, say, 5,000,000 cub. ft. in capacity would differ widely from the "type" ship on which the curves are based, but it is expected that the conflicting tendencies mentioned above would result in the performances being at least as good as those shown in the curves.

In the following, the weight of each item has been shown as a function of N, where N is the ratio of any linear dimension of an airship to the corresponding dimension of a particular airship of similar type and of equal speed, which may be termed the "type" ship.

Outer Cover.—The outer cover is the skin of the airship. Its duties are to protect the framework and interior arrangements of the airship from the weather and from the action of the excessively strong wind produced by her rapid motion through the air; to screen the gas bags from the heating effect of the sun's rays; and to present a fair exterior surface to the passing air stream so as to reduce the resistance of the hull to the lowest possible value.

The last of these functions is of great importance, as calculation shows that about 70 per cent. of the total resistance is contributed by the main hull in a modern airship. Aerodynamic theory asserts that the resistance cannot strictly be divided into skin friction and form resistance in the manner customary among naval architects, but it is certainly true that a large part of the resistance must be closely analogous to skin friction and will depend for its value very largely upon the evenness and smoothness of the outer cover. British rigid airships have not been very satisfactory hitherto in this respect, and we may expect that as outer covers are improved, the resistance coefficients of our airships will be considerably reduced.

The outer cover makes no direct addition to the strength of the airship, but will perhaps be made to do so at a later stage of development. It is made of cotton, or linen, fabric doped on the outside, and is tightly stretched over the hull framework so that it will not unduly bulge or flap under the varying external air pressure occurring during flight. The necessary tension is obtained chiefly by the contracting effect of the final coats of dope, applied after the outer cover is in place on the hull.

As airships become larger, it is probable that more stringent requirements for durability and strength of the outer cover will be laid down, and these may involve the use of dope films much tougher and thicker than any yet suggested, or possibly, thin sheet metal may be used. Such modifications would involve increase of weight, which is neglected here, together with many improvements tending to decrease weight. With increase in the dimensions of airships, the unsupported areas of the outer covers tend to increase also, and it is necessary either to strengthen the material or to give further support by such means as the introduction of additional wires stretched across the panels, close to the inner surface of the fabric, so as to reduce the unsupported areas to a suitable size. The latter course is usually preferable, as in the analogous problems connected with the support of gas bags. Assuming this to be done, the weight per unit area of the material is independent of size of airship, and, neglecting the small error which may result from assuming that the weight of the seams, edges, &c., is a constant proportion of the weight of the cover, we may say that, in similar airships of different sizes, the total weight of the cover varies as N^2.

Gas Bags.—These are made of cotton, or other suitable fabric, lined with goldbeaters' skin. The skin lining is commonly varnished on the gas face to protect it from moisture and also to improve the impermeability. In some cases the outside of the fabric is also varnished to repel moisture. It should be noted that there are several animal tissues, other than goldbeaters' skin, which seem to be equally suitable for skin lining, but it is to be hoped that we may soon be able to avoid altogether the use of animal tissues, which are very difficult to preserve perfectly.

Each gas bag is fitted with a spring-loaded automatic relief valve, usually fitted in the lower part of one of the flat ends. Most gas-bags have also a hand-worked gas valve in the top, used chiefly during landing operations.

The automatic valves open at a predetermined pressure but, if the airship is rising rapidly, the gas pressure will usually continue to rise to a somewhat higher figure depending upon the rate of ascent. In designing the gas bags and their supports, provision must be made for the highest gas-bag pressure which can occur when the airship is ascending at the highest rate required.

The gas bags are supported against the bursting pressure of the gas, partly by the surrounding hull girders and partly by a network of wires filling in the areas between the girders. Sometimes, also, cord nets are fitted as a further support. These supports will be considered later, and the point to notice here is that as a result of their action the tension existing in the gas-bag material at any part is somewhat indefinite and may depend very much on the degree of skill which has been shown in handling the bag into position in the ship. As a rough approximation for design purposes, we assume that the tension in the gas-bag material at any part is a function of the gas pressure at that part and of the spacing of the supports. It follows that the tension may be reduced to almost any extent by multiplying the supports.

It is believed to be the case that, where very light fabric is used, the tension is chiefly borne by the skins. An experiment on the strength of skins gave 150 kg. per metre width for each layer, the weight of the skin being about 20 grammes per square metre per layer. Skins are, therefore, not quite so strong as the best cotton fabrics, weight for weight. Unfortunately, it appears that cotton fabric stretches more than the skin lining before rupture under tension; consequently, if it is desired to rely on cotton fabric to resist the tension, we must have a fabric so strong as to be only lightly stressed by the tension, otherwise the skin lining may split. It appears that the lightest bags are obtained by using the lightest possible fabric, which will take no great part in resisting tension but will simply form a protection for the skins against damage by abrasion, while the skin lining is made sufficiently strong to take up the whole of the tension without splitting, or loss of impermeability.

Generally speaking, it appears that as we proceed to larger ships, the least total weight of gas bags and supports will be obtained by increasing the latter, rather than by using stronger gas bags. We may say, then, that the weight per unit area of the material will remain nearly constant, and that in ships of similar design the total weight of the gas bags will vary approximately as N^2.

Gas-Bag Supports.—A gas bag exerts an outward pressure upon all its supports and the force thereby applied to any member is proportional to the internal gas pressure in the portion of the gas bag bearing upon it. The algebraic sum of the vertical components of these forces is equal to the lift of the gas bag. The manner in which these forces are distributed from the members which first receive them to the main structure, and are finally applied so as to support the weights, not only of the body of the ship, but of the concentrated weights, such as the machinery cars, which occur in the lower part of the hull, presents one of the most difficult studies occurring in airship design. It will only be possible here to indicate one or two aspects of the problem.

Gas-Bag Support Wires.—The longitudinals are about 10 ft. apart round the circumference of the ship at the greatest diameter. The transverse frames are about 16½ ft. apart in a fore-and-aft direction. The curved surfaces of the gas bags are therefore divided by the hull framework into panels about 10 ft. by 16½ ft. amidships, but of reduced width towards the ends of the ship. If there were no support wires or nets across these panels the gas bags would bulge up excessively and the fabric would be subjected to heavy tension. The whole outward pressure of the gas would be transferred by the fabric direct to the girders, which would thus be exposed to heavy bending moments tending to make them bend outwards between the girder joints. To avoid this, wires are stretched at regular intervals across each panel under the girders, so as to be in contact with the gas bag, whose surface is thus split up into a large number of much smaller panels. The fabric tension is reduced by this means to a convenient figure. The wires then receive the outward force of the gas from the fabric and transmit it to the girders in a manner which is under perfect control as described below. There are two systems of wiring in common use, viz., the "circumferential" and the "diagonal."

The "Circumferential" System of Gas-Bag Wires.—Suppose a large number of wires stretched tightly around the circumference of the hull inside the longitudinals at intervals of, say, 2 ft., and connected to the longitudinals only by loose stirrups through which the wires can slide. Then before the gas bag is put in place, the tension of these wires will cause them to exert a force radially inwards on all the longitudinals. When the gas bag is in place and inflated, it will bear more strongly on the top wires and girders than on those at the bottom, and will to a greater or less extent neutralise the inward force of the wires on the upper longitudinals. The tension in the wires will be increased and will exert a stronger inward force than before upon the lower longitudinals where the gas-bag pressure is low. By suitably adjusting the initial tensions in the wires we could arrange that the whole of the lift of the gas-bag would be transmitted by these wires direct to the bottom longitudinals, which would, however, be undesirable, as these girders are usually in compression due to the airship's bending moments.

* Paper read before the Institution of Naval Architects March 25, 1920.

If we had left the wires initially quite slack and had securely fixed them to each longitudinal, so that they could not slide through the attachments, then the whole of the lift would be taken by the upper longitudinals and none by the lower ones. It will be seen that by adjusting the initial tensions of the wires and varying the method of attachment to the longitudinals, using sliding connections at some and fixed ones at others, the lift of the gas bag can be taken at any desired part of the circumference. Probably the lift should be taken partly at the top of the ship and partly at the sides, and this is done in some recent cases. As an example, Fig. 1, below, shows the manner in which the lift is distributed among the longitudinals in a recent design. In this ship the gas bag wiring is designed to deliver a large part of the lift to the longitudinals at the sides, i.e., C, D and E.

The tension in a circumferential wire is given by the formula :

$$\text{Tension} = \frac{P\,R}{L}$$

where P = mean gas pressure per foot run on the area supported by the wire.
L = length of wire between supports.
R = radius of curvature of wire under gas pressure.

In order to keep down the tension and therefore the weight of the wire, R should be as small as possible, i.e., the wire should bulge under the maximum pressure of the gas bag as much as possible without unduly reducing the clear space between the gas bag and the outer cover.

The amount of bulge in these wires has, however, an important effect upon the loading of the longitudinals. For instance, if it happens that at the top of the ship the bulge of the wires on the two sides of a longitudinal is such that R equals the radius of the ship's section measured inside the longitudinals, then it is easily proved that the longitudinal will receive no radial force at all from the wires. If R is less than the ship's radius, the longitudinal will receive an outward force ; if it is more then the force will be inward. The above assumes that the inner faces of the longitudinals all lie on a circle and shows that the initial tensions of the wires must be very carefully adjusted.

A further means of adjusting the loads upon certain longitudinals consists in placing them so that their inner faces are slightly inside or outside the circle on which the other longitudinals lie. This is actually the case in German rigids, where the bases of the main longitudinals lie on a slightly smaller circle than that containing the bases of the intermediates, with the result that the latter girders receive practically no outward force, although the wires are initially rather slack.

The Diagonal System.—In this case the wires are arranged in two sets of rather finely-pitched helices, right and left-handed respectively. The wires are all fixed to the longitudinals where they cross them, and the main difference in effect as compared with the former system is that the wires tend to lead away the gas-bag forces from the centre part of each frame towards the transverse frames. The longitudinals are therefore well supported, provided the wires are correctly tensioned. Apart from this feature the wires operate very much in the manner described for the circumferential system.

Whichever system is used, it may be stated that in similar ships the values of the gas pressure, and of R, both vary as N, and the total weight of the gas bag support wiring varies as N^4.

Main Longitudinals.—The primary function of these is to resist the longitudinal forces produced by the bending moments and shear forces in the hull due to (*a*) the static loading, and (*b*) the aerodynamical forces acting upon the ship.

(*a*) These are most severe in the light condition of the ship, and are chiefly due to the concentrated weights of the machinery and control cars and of the tail. The weight of the control car is practically independent of N, while that of the machinery varies as N^2, as shown later, and that of the tail as N^3. The extent to which the loads in these longitudinals are the result of tensions in the diagonal wires produced by shear forces in the ship, and of bending of the ship as a whole, is not quite definite. Generally, it appears fair to assume that on the average the concentrated loads vary as N^2, and this would cause the weights of the main longitudinals to vary as N^3.

(*b*) The bending moments and shear forces due to aerodynamic loading in similar ships flying at equal speeds vary as N^3 and N^2 respectively, and the weights of longitudinals to withstand the resulting forces will also vary as N^3.

The main longitudinals have other functions, such as resisting the horizontal resultant pressure of the gas bags acting upon the curved ends of the hull, and of resisting lateral bending due to the gas-bag support wiring, but, on the whole, the weight may, it is thought, fairly be assumed to vary as N^3.

Intermediate Longitudinals.—The forces occurring in the transverse wiring of a main transverse frame do not load all the joints of the frame uniformly. It is, therefore, desirable to make the number of the sides of the polygon as small as possible. On the other hand, the efficiency of the ship is greater the nearer the form of section approximates to a circle, i.e., the greater the number of the sides of the polygon. Both these conflicting requirements are met adequately by the system adopted in most recent airships. The main transverse frames have 13 sides including the bottom one, and through the joints 13 main longitudinal girders run fore and aft. The framework consisting of these two sets of members, in conjunction with the hull wiring, forms the main structure of the ship. To make the section more nearly circular, and so to get more gas bag capacity, intermediate longitudinals are run midway between the main ones, except on the bottom face of the ship, and are placed so that their outer edges are on the circumscribing circle of the section. The section of the ship is therefore 25-sided as far as the external form and the gas bags are concerned, and high efficiency is obtained for a moderate weight. The intermediate longitudinals are supported at each transverse frame and at the intermediate transverse frames which are 25-sided. The gas-bag support wires are, of course, attached to both sets of longitudinals.

It will be seen that the intermediate longitudinals perform auxiliary functions only. The loads upon them are chiefly lateral, due to residual reactions from the gas-bag wire tensions and to the tensions of the outer cover and its supports, and are rather indefinite in most cases. The scantlings of these girders are settled, therefore, rather by judgment than by calculation, and their total weight may be assumed to vary as N^3. It is to be noted that these girders, being supported at the main transverse frames, may apply a lateral load to the latter at the middle of each side of the polygon. Chiefly for this reason, the main transverse frames have king posts and trusses fitted to each of the girders composing them.

Main Transverse Frames.—Each of these frames is fitted with a system of wires which maintains its polygonal shape, enabling it to fulfil its principal function of preserving the transverse sectional form of the ship. These frames are the strong rings in the structure, and concentrated loads, such as engine cars, are usually suspended from them rather than from intermediate points. Their wiring, which is mainly radial in disposition, is occasionally called upon to support end pressures resulting from a difference of pressure between adjoining gas bags, and the heaviest compressive forces in the frame girders arise from this cause.

When one gas bag is deflated and the adjacent one is just full, the tension in one of the wires of a radial system in a transverse frame is given by :

$$\text{Tension} = C\,\sqrt[3]{A}\,.\,R^2.$$

where C = a constant.
A = sectional area of the wire.
2R = mean diameter of gas bag.

In similar ships, to obtain the same stress in the wires, $\frac{A}{R^3}$ must be constant, and the tension will then vary as R^3. The wire tension produces a compression in the transverse frame girder, which also varies as R^3.

The wires have also to support a proportion of the weights carried in the corridor or suspended from the under side of the frame ; they serve, in fact, to suspend these weights from the upper part of the frame. Such weights vary as N^2 or as N^3, according to their nature.

The main transverse frames are also loaded by the tensions in diagonal hull wiring attached to them, but the forces so produced are of minor importance, except when they accompany the much heavier forces caused by difference of pressure between adjoining gas bags.

It is considered, therefore, that the main transverse frames and their wiring may be assumed to vary in weight as N^4.

Intermediate Transverse Frames.—The main function of these is to support the longitudinals where the diagonal hull wiring crosses them, or is attached to them, at points intermediate between the main transverse frames.

The loading of an intermediate transverse frame is somewhat variable round the perimeter of the ship. At the top of the ship the frame girders will be in slight compression or even in tension due to the upward force of the gas bag ; the gas bag will also press upon the girder itself to some extent and produce some lateral loading. At the sides of the ship the main forces in the frame are usually compressive, due to the tensions in the diagonal hull wiring. These wires in crossing a longitudinal pass from one face of the hull to the next, and so the two faces are inclined to one another. The wires exert a force tending to move the longitudinal inward, and this produces a compressive force in the two members of the intermediate transverse frame meeting the longitudinal at that point. In the lower part of the ship's sides the diagonal wire tensions will tend to put the members of the frame in compression, but heavy weights carried in the corridor would naturally tend to produce tension in the frame.

Generally, the inter-transverse frame is designed to withstand the compression due to the wiring combined with some lateral loading from the gas bag. Both components of load vary as N^3 in similar ships, and the weight of the frame will therefore vary as N^4.

Hull Diagonal Wiring.—The main function of this wiring is obviously to prevent the panels formed by the intersecting transverse and longitudinal girder systems from distorting under the shear or torsion forces existing in the ship due to static or dynamic loads. Although all the girders are continuous through the joints, the structure would have very little stiffness under shear or torsion if the wiring were omitted, and experiment shows that the wiring must be assumed to take practically the whole of such forces, except at the ends of the ship where the longitudinals are inclined inwards towards the axis, and are thereby enabled to take an appreciable part of the shear. In addition the wiring takes a part in the distribution of various local forces acting upon the structure. The calculation of the forces acting in the various wires is an exceedingly complicated matter, and discussion of it must be reserved for a future occasion. Generally the tensions of the wires in similar ships varies as N^3, and the total weight of the wires therefore varies as N^4.

Corridor.—The functions of the corridor were at one time the subject of much debate. It is, however, now clear that from the structural point of view the corridor must be regarded as being primarily a distributor of concentrated loads. It receives the weights of the control car, petrol tanks, water ballast, bags, &c., and at least a part of the engine car weights ; also the pull of the trail and handling ropes when the ship is being handled on the ground—which in future will happen but rarely. These forces it distributes to the various points at which it is supported, i.e., to the main transverse frames and, in a much less degree, to the intermediate transverse frames. It may be noted that as ships have progressively been built lighter, the weights carried in the corridor have increased, and its structure has required careful attention in design. In similar ships the weights taken by the corridor vary only slightly faster than N^3, and are here assumed for convenience to vary as N^3. The loading per metre run of corridor, therefore, varies as N^2, and the resulting bending moment as N^4. Hence the weight of the corridor varies as N^4.

Fins, Rudders and Elevators.—These have been discussed at some length in a paper recently read before another society. In similar ships the areas vary as N^2, but at equal speeds the air pressures per unit area are

R.38.

DISTRIBUTION OF THE LIFT IN LBS. PER FOOT RUN ON LONGITUDINALS IN PARALLEL BODY.

Fig. 1.

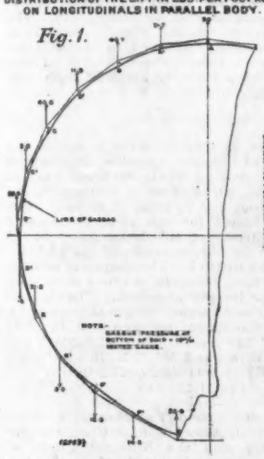


Fig. 2.

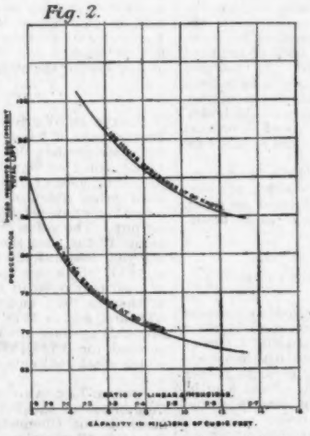


Fig. 3.

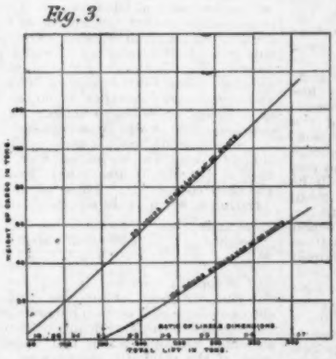
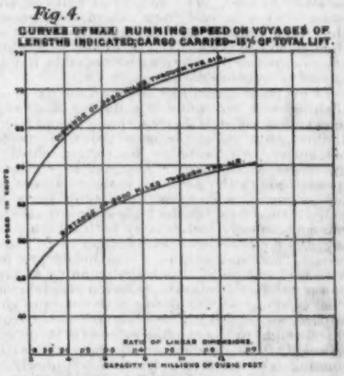


Fig. 4.



equal, hence the weights will vary as N^3. The pressures on the rudders and elevators will vary as their areas, i.e., as N^2, and the turning moments about their axes as N^3. The forces in the control wiring and gears will therefore vary as N^2, and the weights of the controls will vary nearly as N^3. The weight of minor controls is assumed to follow the same law.

Electric Installation.—This weight follows no precise law, but may be assumed to vary as N.

W/T Installation.—The weight of this is independent of N.

Mooring Gear and Trail Ropes.—The greatest loads in these will result from wind pressures acting upon the airship, and will consequently vary as N^2. The weight of this item will therefore vary as N^2, as there is no reason to assume that increase in length or quantity of the gear carried in the ship will take place with increased size of the latter. The greater part of the weight will probably be due to the bow mooring gear.

Machinery.—As already stated in dealing with outer covers, it is calculated that about 70 per cent. of the total resistance of a modern ship is due to the main hull, the remainder being contributed by the appendages. In similar ships at equal speeds the resistance of the hull varies as N^2, and it may be assumed that the same law is followed by the main appendages, *i.e.*, by the fins, rudder and elevators, and the machinery cars. A few items such as the control car have resistance independent of N. It may be observed that, in so far as skin friction may be considered to play a part in air resistance, the co-efficient of resistance should reduce as length of surface is increased, in proceeding to larger airships. Taking a conservative view, it is assumed that the total resistance of similar airships at equal speeds will vary as N^2. Assuming also that the propulsive coefficient is constant, the total brake horse-power will vary as N^2. The machinery installation is divided into a number of self-contained units each carried in a separate car slung from the under side of the hull. General descriptions of such units have already been published, and need not be repeated here. The number of units requires careful consideration in each new design, but generally it is thought preferable that the number should not be less than three nor more than six, except in very large ships where a greater number may be desirable, if only to avoid excessive propeller diameters.

The type of machinery required for naval or military airships will no doubt be lighter and slightly less economical and reliable than that adopted in commercial airships, but in either case the total power of the machinery will probably be settled chiefly by consideration of the power required to realise a certain speed through the air continuously as long as the fuel supply lasts. An engine for airship purposes will be judged, therefore, by the highest power at which it can run continuously and reliably with a high economy for, say, 100 hours or more, rather than by full power bench tests. The total weight of the machinery installation with fuel and oil for 100 hours' running at the required power will be taken as the criterion of machinery weight. Fuel economy at this power is therefore of the greatest importance, and must be obtained even if considerable extra weight in the machinery itself is involved. This is especially true in commercial ships where the cost of running is a vital consideration. Similarly, propellers should be designed for highest efficiency at the power for continuous running rather than at full power. In considering possible future progress in machinery for airships, account must be taken of the possibility of using fuels other than petrol, and of thereby reducing running costs, while diminishing the risk of fire, which is never quite absent where petrol is employed. Feathering and reversible propellers offer very great advantages in airships, and will, no doubt, come into use before long. Apart from improvements of such a nature, it is safe to suppose that in future the consumption of fuel per brake horse-power will not exceed 0·5 lb. at the power for continuous running.

Table of Fixed Weights.

Item.	Variation with Size.
Outer cover	N^2
Gas bags	N^2
Gas bags wiring	N^4
Main longitudinals	N^3
Inter-longitudinals	N^3
Main transverse	N^4
Inter-transverse	N^4
Hull diagonal wires	N^4
Corridor	N^4
Fins, &c.	N^3
Electrical equipment	N
Wireless equipment	N
Mooring fittings	N^2
Machinery and cars	N^2
Petrol and oil systems	N^2
Control car and instruments	N
Controls	N^3

The future weight per brake horse-power of the machinery is not so easy to estimate, as no installation meeting the requirements outlined above has yet been fitted. Making a liberal allowance for extra weight to meet these requirements, the curves in Figs. 2, 3 and 4 have been drawn on the assumption that the weight per brake horse-power of machinery including engine cars and watch-keepers, will be 14 lb., based on the maximum continuous running power, and that the total weight varies as N^2. The same law has been applied in estimating the consumption of fuel and oil, which has been taken to be 0·53 lb. per brake horse-power per hour, plus 3 per cent. for tare of containers. The total weight of the petrol and oil systems, apart from those portions carried in the cars (which are included in the machinery weights), will vary approximately as N^2.

Summary.—The principal items of the fixed weight of a ship have now been considered, and the manner in which they vary respectively with N is shown in the table in the preceding column.

CONCLUSION.

Collecting the various items in groups, according to functions of N, the following equation is obtained:

$$F = A + BN + CN^3 + DN^3 + EN^4 \quad . \quad (1)$$

where F is the total of the fixed weights of a ship, and A, B, C, D and E are constants depending on the type of the ship.

To express the total fixed weight in its more useful form as a percentage of the total lift, put:

Total lift = $W N^3$ where W is a constant.

Then:

$$\frac{100\ F}{\text{Total lift}} = \left\{ \frac{A}{WN^3} + \frac{B}{WN^2} + \frac{C}{WN} + \frac{D}{W} + \frac{EN}{W} \right\} \times 100 \quad . \quad (2)$$

If the weights for a single ship of a type are known, this equation enables the total fixed weights to be expressed as a percentage of the total lift for any ship of the same type, whatever its size. It will be noticed that W in the above is the total lift of the "type" ship.

In the case of airships generally similar to R 38, but with machinery designed to give a continuous running speed of 60 knots, the above equation becomes:

$$\frac{\text{Total fixed weight}}{\text{Total lift.}} \times 100 = \frac{0{\cdot}33}{N^3} + \frac{0{\cdot}43}{N^2} + \frac{23{\cdot}35}{N} + 8{\cdot}06 + 10{\cdot}19\,N \quad (3)$$

This equation gives results showing the percentage is fairly constant over a very wide range of total lift. Broadly speaking, it may be stated that the percentage may have a value of slightly under 40 for all sizes of ship from 5,000,000 cub. ft. to over 15,000,000 cub. ft. For sizes below 5,000,000 cub. ft. the percentage is rather above 40, being about 44 for a ship of 2,000,000 cub. ft.

This is a most satisfactory result, and enables the development of large airships to proceed with the assurance that full advantage will be obtained from the important fact that the weight of fuel and oil required for a voyage of given duration varies as N^2. To illustrate this gain, the curves in Figs. 2 and 3, page 465, have been drawn: Fig. 2 shows the total weight of the airship *ex* cargo when fully equipped for voyages of 50 hours' and 100 hours' duration at 60 knots speed expressed as a percentage of the total lift; Fig. 3 shows the actual cargo weights for the same voyages.

The equations for the curves in Fig. 2 differ from equation (3) owing to the inclusion of the weights of crew, ballast, petrol, oil and other items required to equip the ship completely. Thus, for a voyage of 50 hours' duration at 60 knots the equation becomes:

$$\frac{\text{Total fixed weight}}{\text{Total lift.}} \times 100 = \frac{1{\cdot}99}{N^3} + \frac{0{\cdot}43}{N^2} + \frac{54{\cdot}49}{N} + 17{\cdot}09 + 10{\cdot}19\,N$$

For certain purposes it may be desired to increase the running speed of airships, rather than to increase the cargo beyond a certain percentage. In Fig. 4, curves have been drawn showing on a basis of total lift the speeds at which airships can be run, carrying a cargo 15 per cent. of the total lift, on voyages of two fixed lengths equal to the distance which a 60-knot airship would travel in 50 hours and 100 hours respectively.

These curves show clearly the great importance of developing airships in the direction of greater size as rapidly as possible. They also show that, if this is done, airships are capable of playing a leading part in the development of transport by air over long distances.

INCREASED MOTOR TAXATION.—With reference to this question, the Automobile Association and Motor Union state that in December last their Executive Committee, after carefully investigating various alternative forms of taxation, unanimously resolved that the most equitable method was to be found in the continuance of the tax upon imported motor spirit. This decision was communicated through the proper channel to the Government Department concerned, and the attitude therein adopted has been firmly adhered to from the first. Consistent with that decision the association has always held: (*a*) That the special taxation of motor vehicles is a road tax, and it therefore follows that each individual tax should, as far as possible, be directly proportionate to the extent of road wear. (This cannot possibly be achieved by the imposition of a heavy initial tax.) (*b*) That the payment of a lump sum per car upon a horse-power basis operates harshly upon (1) persons of moderate means owning low-priced cars, (2) owners of old second-hand cars used mainly for shopping, station work, &c., (3) persons owning two or three cars, only one of which is on the road at a time. (*c*) That the continuance of taxation on imported motor spirit is of vital importance as ensuring the retention of preferential treatment for home-produced motor spirit, the increased production of which is so important a factor in the solution of the fuel problem. (*d*) That any tax which unduly penalises the motorist of moderate means will cause the withdrawal of many motor vehicles from the road, limit the purchase of both new and second-hand cars and motor cycles, and will thereby result in a restriction of output and a reduction in the revenue which would otherwise be obtainable. The foregoing indicates the Automobile Association and Motor Union's definite policy, but if the Government finally decides to discontinue taxation on motor spirit, the association in common with its colleagues on the Motor Legislation Committee, will maintain that any alternative system must be conditional upon State control of supplies and prices of motor spirit on the lines of the recommendations of the Petrol Profiteering Committee.

ON THE POLISHING AND ETCHING OF ZINC FOR MICRO-EXAMINATION.*

By H. H. HAYES, Member (Birmingham).

OWING to the rapid increase in the industrial use of zinc in the form of thin sheet, it was found imperative to develop a rapid method of polishing and etching this material in order to study the effects of different methods of annealing.

Polishing.—No difficulty is experienced in the polishing on the standard French emery papers, but after this stage numerous difficulties arise, the greatest being, of course, the removal of scratches. Numerous polishing powders and methods were tried, but the following method was the one finally adopted. Assuming that the section has been carefully polished on the 0000 paper, the next stage is carried out by rubbing on chamois leather smeared with "Globe Polish," and finally with the tip of the finger in the usual way. Clean with ether (free from water), and dry in hot-air blast or on linen. The surface will now appear quite bright and comparatively free from scratches. The few scratches which remain will not seriously interfere if it be required to examine the section before etching. It is absolutely imperative that water be kept away from the polished surface before etching, because even distilled water produces a tarnish, so that the use of alumina or magnesia with water on parchment or chamois leather is impossible.

Etching.—The development of the etching method is due largely to my assistant, Mr. A. L. Fawkes, who, during the analysis of zinc for impurities noticed that after the first violent reaction, when dissolving up in nitric acid had taken place, the fragments of zinc had their coarse crystalline structure revealed in a very distinct manner. This clue was followed up, nitric acids of varying specific gravities were tried, the one finally adopted being 1·5 specific gravity, approximately, more commonly known as fuming nitric acid. The method of etching is very simple. The microsection is held in zinc-tipped forceps, immersed in the acid for 1 second, and immediately rinsed in water and dried by a hot-air blast, a method practically identical with that of Sauveur for the etching of steel.

MINING IN WESTERN AUSTRALIA.—The report of the Department of Mines of Western Australia, for the year 1918, states that the quantity of tin exported was 415 tons, valued at 76,952*l.*, an increase in tonnage on the preceding year of 32 tons and in value of 31,664*l.* The good price which obtained for this mineral rendered many low-grade propositions payable, hence the improved output. The value of the copper exported was 66,146*l.*, being 19,592*l.* less than in 1917. The output of coal for the year was 337,039 tons, being 10,489 tons more than in 1917, which was the largest on record. The number of men employed in the collieries, 618, was greater by 47 than in 1917, and the output per man was, in 1917, 572 tons, and in 1918, 545 tons. The total value of the minerals produced in 1918 was 4,265,577*l.*, in which gold entered for 3,723,183*l.*; it was 4,629,027*l.* in 1917, in which total gold entered for 4,121,645*l.*

INCOME-TAX AND SCIENTIFIC EXPENSES.—A Joint Committee of the British Association of Chemists, the Institute of Chemistry and the National Union of Scientific Workers, is putting forward the claim that the following expenses should be treated as a charge against income in arriving at the assessment of those who earn their livings either by purely scientific pursuits or by the application of science to industry: (1) Subscriptions to scientific and technical societies, libraries and periodicals; (2) purchase and renewal of scientific and technical books, instruments, apparatus, chemicals and other materials; (3) rent and expenses of laboratory or study; (4) travelling and other expenses incurred in attending scientific meetings or congresses; (5) provision of special clothing and renewal of clothes damaged in the course of employment; (6) other expenses incurred in the course of research. The general secretary of the British Association of Chemists would be glad to receive information with regard to special cases in which any of the above have been definitely allowed or refused. Replies should be addressed to Bedford House, Yorkplace, London, W.

SCIENTIFIC AND TECHNICAL BOOKS.—One part of the descriptive catalogue of the British Scientific Products Exhibition, organised by the British Science Guild last year, was devoted to selected lists of books on science and technology. The Guild has been asked to extend these lists, so as to include not only all branches of science—both biological and physical—but also the chief technical subjects. It has undertaken to do this; and a committee, of which Sir Richard Gregory is chairman, has been appointed to prepare such a catalogue. The lists will be limited to books of British origin actually in current catalogues of the publishers, so that they can be obtained in the usual way through booksellers. School books and elementary manuals will not be included, and the general standard will be that of college courses in scientific and technical subjects, or of works' libraries. Each list will be submitted to authorities upon the subject with which it deals, but in order to secure that no important work is omitted, the committee invites the assistance of everyone interested in its task. Such aid may be afforded by sending to the British Science Guild, 6, John street, Adelphi, London, W.C. 2, lists or single titles of British books of standard value or proved worth in any branch of science or industry.

* Note read before the Institute of Metals, March 12, 1920.